

Purdue University

Purdue e-Pubs

Historical Documents of the Purdue
Cooperative Extension Service

Department of Agricultural Communication

1-1-1900

Recommended Practices & Programs for Sheep Producers in Indiana and the Midwest

Purdue University Cooperative Extension Service

Follow this and additional works at: <https://docs.lib.purdue.edu/agext>

Purdue University Cooperative Extension Service, "Recommended Practices & Programs for Sheep Producers in Indiana and the Midwest" (1900). *Historical Documents of the Purdue Cooperative Extension Service*. Paper 167.

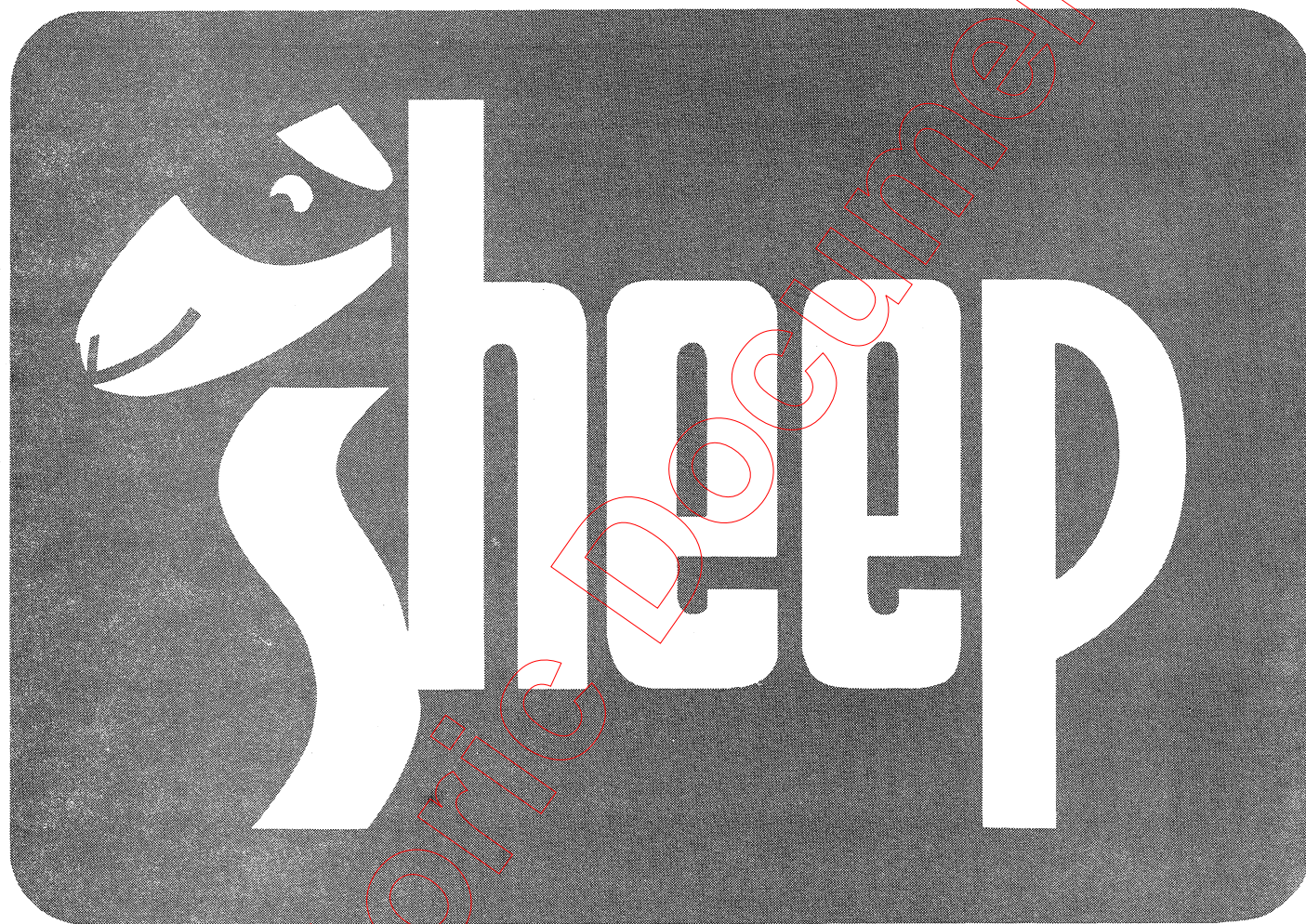
<https://docs.lib.purdue.edu/agext/167>

For current publications, please contact the Education Store: <https://mdc.itap.purdue.edu/>

This document is provided for historical reference purposes only and should not be considered to be a practical reference or to contain information reflective of current understanding. For additional information, please contact the Department of Agricultural Communication at Purdue University, College of Agriculture: <http://www.ag.purdue.edu/agcomm>

This document has been made available through Purdue e-Pubs, a service of the Purdue University Libraries. Please contact epubs@purdue.edu for additional information.

Recommended Practices & Programs



**FOR SHEEP PRODUCERS
IN INDIANA & the MIDWEST**

Selection and Breeding Programs

*K. J. Drewry
Animal Sciences Department*

Introduction

Genetic improvement, although slow compared to the possible environmental improvements (i.e. nutrition and management), is cumulative and permanent. The number one goal of the sheep industry must be to increase the genetic potential of sheep to produce. The genetic potential sets the upper production limit which can be obtained by improvements in environmental factors.

Methods of genetic improvement-selection and mating systems

The genetic potential of sheep can be changed by two ways:- (1) selection and (2) mating systems. Although mating system is independent of selection we must consider mating systems at the same time we consider selection. Mating system refers to the relationship between animals that are mated. Animals may be mated that are (1) alike on basis of pedigree (inbreeding or linebreeding) or (2) unlike on basis of pedigree (out breeding or crossbreeding). Animals may be mated because they are: (1) alike in terms of records or (2) unlike in terms of records.

Selection is differential reproduction. For selection to be effective genetically superior animals must be chosen as parents. Genetically superior animals are those who transmit to their offspring the kind of heredity that enables the offspring to be superior in the existing environment. The transmitting ability or breeding value can only be inferred from the record(s) of the individual or its relatives.

Rate of genetic improvement from selection

The rate of genetic improvement from selection depends upon three factors; (1) accuracy, (2) intensity, and (3) variability. Accuracy in estimating the breeding value of the individual from its record is determined by the amount of the total variation that is due to genetics or heredity. When heritability of a trait is high, then more emphasis should be placed on the record of the individual. When heritability of a trait is low, emphasis should be placed on the record of the individual, its relatives and progeny if these are available.

Intensity is determined by the proportion of the animals chosen to be parents of the next generation. Intensity with a given trait, is decreased as the number of traits under selection increases. With sheep approximately 40 to 50 per cent of the ewe lambs weaned are retained for replacements compared to 2 to 5 per cent of the ram lambs.

The amount of variability observed for traits under selection determines the directional change from selection.

Traits to be emphasized

The traits of most concern in both commercial and purebred sheep production must be those of most economic importance. An industry that is struggling for its very existence cannot justify "fads and fancies" and "must devote its efforts to improving efficiency of meat and wool production." The traits which should be of concern to the U.S. sheep producers are:

(1) Traits which merit attention in all breeds and production situations:

- (a) prolificacy
- (b) growth rate and factors affecting it - including milk production of the ewe.

(2) Traits which are important in most situations but may not be considered in stocks used largely to provide sires of crossbred market lambs:

- (a) fleece weight
- (b) wool fiber length, diameter and quality

(3) Traits which merit attention in breeds to produce sires of crossbred market lambs:

- (a) high ratio of lean to fat and bone, consistent with good keeping quality of the carcass
- (b) desirable eating quality of the meat
- (c) large loin eye area
- (d) high dressing per cent

(4) Traits which merit attention in breeds or flocks only when they constitute a problem:

- (a) face cover
- (b) skin folds

(5) Traits which may be of great importance but for which the level is affected more by choice of breed than by selection:

- (a) breeding season
- (b) flocking instinct
- (c) conformation and ability to finish at a particular weight.

Prolificacy

Prolificacy is important for three reasons. First, the greater the number of lambs born and raised the greater the net income per production unit. Secondly, an increased reproductive rate permits more intense selection, hence greater genetic improvement in other traits. Thirdly, the shorter generation interval and the potential for multiple births are two of the sheep's greatest advantages compared to its most important competitor, beef cattle.

Heritability estimates of prolificacy have been observed to be low ranging from 0.05 to 0.20. Research reports indicate that prolificacy does respond to selection more rapidly than the low heritability estimates might suggest. Selection for twinning resulted in an increase of 20 to 30 per cent in one generation between high and low lines of Merinos in Australia, and an increase of 15 per cent in each of two flocks of grade Targhees in California over a five year period. In England, selection for number of lambs weaned per ewe was increased from 0.85 to 1.11 in a flock of Romneys over a period of 15 years. A study in New Zealand, with Corriedale sheep, showed that twinning increased linearly with increased live weight of the ewe at rate of about 6 per cent for each 10 pound increase in body weight.

Growth rate

The importance of growth rate is obvious. Sheep are sold by weight and although there is some variation in price per pound due to finish and conformation their effect on income is much less than that from differences of weight at a given age. Increased growth rate leads to one of two results. One, marketing animals at the same weight but younger ages will mean a shorter feeding period with lower attendant risks and will usually result in higher quality meat. Alternatively, marketing heavier lambs at the same age would result in a lower per pound slaughtering and processing cost with more attractive cuts from loin and rack. Increased weight of leg would probably require additional fabrication procedures.

The faster gaining lambs normally convert feed more efficiently than slower gaining lambs. Thus, growth rate, which is an easily measured trait, can be used as an indicator of an important but difficult to measure trait, feed conversion. Rate of gain and thus efficiency of lamb is strongly influenced by the milk production of the ewe and the genetic potential of the lamb to gain. Early gain of up to 40 to 60 pounds is influ-

enced largely by the milk production of the ewe with very little ram influence. Gain after 9 to 10 weeks of age is influenced by the lamb's genetic potential for growth, that is, ram influence is greater.

Growth lambs often come from parents with a large body size who themselves eat proportionally more throughout the year. An increase in rate of gain in the lamb may be uneconomical if it is obtained with an increased mature size of breeding animals.

Selections on growth rate should be made at an early age because: (1) early weight gains are more economical, (2) early selection of breeding animals shortens the generation interval, and (3) selection for rate of gain at an early age does not automatically result in selection of larger mature animals.

The heritability of lamb growth rate is medium (0.20 to 0.30) in magnitude. Research results indicate that heritability estimates for "early lamb gain" is not quite as high as "late lamb gain." Other research indicates that when maternal influences are accounted for that the heritability estimates for "early lamb gain" is as large as those for "late lamb gain."

Wool quantity and quality

Fleece traits in sheep will generally encompass grease or clean weight, staple length, fiber diameter and various other quality considerations. Heritability of fleece traits is high (0.40 to 0.50) in magnitude and suggests that good response to selection can be expected when selection is based directly on individual performance. Yearling fleece weights (grease weights in uniform flocks of fine wool ewes with low culling levels and clean weights in flocks producing stud rams where culling level is higher) provides a satisfactory basis for selection.

Income received from sale of wool-- approximately 1/5 to 1/3 of the gross income-- is affected by two variables, weight and price. Weight is the single

most important factor and staple length ranks second because of its contribution to both weight and price.

The long-term importance of wool is difficult to assess. Substitutes for wool are more readily available than substitutes for meat, and it seems probable that the importance of meat from sheep will increase relative to that from wool.

There is apparently little or no increase in wool quantity and quality due to heterosis since crossbreds tend to be the average of the breeds or kinds of sheep crossed to produce them.

Research results have shown that selection for fleece weight in some breeds will result in coarser, less desirable fleeces. However, market price differentials to the grower for fleece quality and fleece fineness may not justify their consideration in selection.

Carcass merit

The most important items to consider when assessing the genetic improvement of carcass and meat quality of lamb are the yield of lean meat per unit of carcass weight and the eating quality from the standpoint of long-term competitive position of lamb. Within existing weight and grade standards, the amount of fat on the carcass dwarfs in importance other carcass measurements in determining carcass value. Differences in fat trim account for 75 to 85 per cent of the differences observed in lamb carcass retail yield. The per cent fat, muscle and bone in the average lamb carcass is approximately 28, 56 and 16 per cent respectively.

Market discrimination is more often related to factors such as health or weight rather than grade. Grade of lambs is the result of their past health status, past feed conditions and their inherited conformation. If the first two factors are satisfactory, the latter usually will not result in a price difference and a wide variety of kinds of lambs will bring about the same price per pound.

Heritability estimates for carcass traits are low to medium in magnitude, ranging from 0.20 to 0.60. Unfortunately, many of the traits of carcass merit can be measured only on the dead animal. Thus, effective selection programs for carcass merit traits must be based on the progeny test.

Four factors, alone or in combination, will lead to increased emphasis on carcass merit traits: (1) development of easily applied live animal measures which accurately predict carcass composition and meat quality, (2) modification of the marketing system so that animals with superior quality return a premium to the producer, (3) larger, better financed breeding enterprises, which could set up an effective testing program and afford the investment of time and money necessary to develop superior meat strains, and (4) development of semen storage, estrus synchronization and management practices to the point where artificial insemination becomes feasible on a large scale.

At the present time, selection for growth rate is one of the most practical procedures to use when selecting for carcass merit since the amount of fat in the carcass, with adequate health and feeding regimes, is determined by the relative position of the lamb in its growth curve. During lamb growth, as with other meat producing species, priority is given to bone, muscle, and fat development, respectively.

Face cover and skin folds

Both excessive face cover and skin folds produce an adverse effect on production. The presence of these traits in a flock is the result of past mistakes in selection programs. The heritability estimates for these traits are of such magnitude that considerable progress has been made in correcting these errors (at the expense of emphasis on other important traits) but continued selection pressure is needed to eliminate these defects from some otherwise useful breeds.

Effective Use of Breeds and Crossbreeding of Sheep

REGISTERED SHEEP

The primary purpose of the registered sheep of the various breeds is to serve as a storehouse of different combination of germ plasm. Each breed represents a particular combination of germ plasm, and the animals within a breed are more like each other than they are like animals of another breed. Breed(s) can make a contribution to the sheep industry to the extent that the breed(s) have hereditary characteristics that are better than the commercial sheep possess. Breed(s) have their influence on the genetic makeup of the sheep population primarily through: (1) breeding-up, (2) crossbreeding, (3) corrective breeding and (4) new breed formation. Thus the genetic makeup of the sheep population is determined primarily by the rams selected to sire ewes in the flock and female replacements.

Breeding-up or grading-up is the mating system used to produce the high grade flocks which we have today. After 5 generations, 20 to 25 years, the genetic makeup of the females in the flock is over 96 per cent that of the breed of ram that were used. Thus, the genetic worth of the flock is determined by the merit of the rams selected. This includes how good the ram breed was, how good the ram(s) selected were compared to the breed average, and the amount of female selection practiced. The future use of grading-up would appear to be limited.

Corrective breeding is used in both purebred and crossbred production programs when the producer realizes that his flock is deficient in some trait and makes an outcross so as to introduce excellence for the given trait. Hopefully, the rams used will not be deficient in other important traits. Rigorous selection must be maintained to retain the introduced excellence.

New breed formation is time consuming, very expensive and must be based on

a broad genetic base. The question to be answered prior to initiating new breed formation programs is, should efforts be devoted to improving traits of available well adapted stocks by the best program of selection and cross breeding that can be devised or should the germ plasm from other breeds be incorporated. Several foreign breeds offer genetic potential for improvement of U.S. Sheep in the areas of fertility or prolificacy, ability to breed out of season and milk production.

Finnish Landrace is a good example of a foreign breed which may offer potential to U.S. sheep production programs. This breed is very prolific with an average of 3.4 lambs per parturition. The list of traits in which this breed is deficient for U.S. production conditions include growth rate, ability to fatten, fleece weight, wool quality and very probably adaptability to range conditions.

Systematic crossbreeding is the best mating system for many commercial sheep production programs since it appears that there is heterosis for most of the very important traits. Production programs developed should maximize heterosis. When several breeds are used in a systematic crossbreeding program, the manner in which the breeds are used becomes very important. All of the present sheep breeds or types will contribute to the crossbreeding program in some manner. Adaptability of the animal(s) to the environmental conditions under which they are to produce does not appear to be warranted aside from selection for performance under production conditions.

The most prevalent breeds of ewes are Cheviot, Columbia, Corriedale, Dorset, Hampshire, Merino, Rambouillet, Shropshire, Southdown, and Suffolk. The most prevalent breeds of rams used are the Hampshire, Corriedale, Suffolk, Rambouillet, Columbia and Dorset.

Most of the commercial ewes in the range country carry some fine wool breeding. These may be grade Rambouillet or Merino in the southwest; Lincoln-Rambouillet, Lincoln-Merino, Corriedale, Columbia, Targhee, Panama-and crosses of these

breeds with the Rambouillet throughout the west and especially in the areas where feed may be more plentiful. In many areas of the west there are "black-face ewes" which have resulted from crossing the "western ewe" with the Hampshire or Suffolk rams. The larger farm flocks --200 ewes and upward--are commonly "western ewes" or "blackfaced ewes" which have been shipped in from the range country.

Adapted crossbred ewes are more fertile than straight bred ewes and crossbred lambs exhibit greater viability than straight bred lambs. Maximum production in commercial flocks will be obtained by the use of about three breeds with crossbred ewes being mated to unrelated rams.

Breeds used in the formation of the crossbred ewes should have: (1) reproductive efficiency (time of breeding, conception rate/time, and lambing rate), (2) milk production, (3) maternal instinct and (4) wool quality and quantity. Breeds which exhibit the above traits to varying degrees are the Rambouillet, Merino, Columbia, Corriedale, and Targhee. These could serve as the foundation ewe breeds.

The first generation or F₁ ewes (cross bred ewes) result from the cross of foundation ewe breeds or crosses with Dorset or Suffolk breeds. On a world wide basis the Leicester breed is noted for mating to "fine wool type ewes" to produce the F₁ ewes.

Ram breeds to be used on foundation ewe crosses or F₁ ewes would be the Suffolk, Hampshire, Shropshire, Southdown and other meat type sheep. Traits to be emphasized in selection of ram breeds are: (1) growthiness, (2) carcass quality, (3) sexual aggressiveness, and (4) male fertility.

Performance Testing and Sire Evaluation Techniques

Performance testing (performance recording) can be defined as any attempt to measure and record the animal's ability to perform. Information obtained must be

used in the selection programs in order to have real value. Performance testing should be based primarily on the individual records for these traits of greatest economic importance. The testing program should be designed for general use by the industry, with special attention given to the improvement needs of the purebred breeds. Specific features of the general performance testing program would be to provide recorded data to the breeder that are accurate, easily understood and readily available so effective selection decisions can be made on a within flock basis. To insure these features, it is highly recommended that centralized data processing be utilized so more complete data are available requiring the least amount of hand calculation. This becomes essential so large numbers of flocks of various sizes can cooperate and function with standardized procedures for data adjustments and uniformity of reporting throughout the industry. Adjustment of records for certain environmental factors such as age, type of birth and rearing, age of dam and sex may be necessary to make accurate selection decisions.

The general effectiveness of a uniform performance testing program in the industry will largely depend upon the acceptance by those flocks that have the largest impact on the sheep population. Studies of various breed(s) and/or populations have shown that their genetic potential depends almost entirely on the breeding practices of a few elite flocks that dominate the breed or population. In one study in England, researchers found that two rams out of a total of 17,000 registered from 1899 to 1954 accounted for 25 per cent of the genes present in the Leicester breed. A similar study of the Rambouillet breed in the U.S. shows that 50 per cent of the genes in the Rambouillet breed came from 31 foundation animals. This stresses the importance of the elite producers in guiding the genetic improvement of their particular breed of sheep.

When records from several individuals are obtained which are from more than one sire and these data are organized to analyze by sire group, then a performance

test automatically becomes a progeny test. Progeny testing and sire evaluation is necessary for those characteristics such as fertility, mothering ability and milk production, and so forth, which can only be expressed in the female or for characteristics such as carcass merit which can only be expressed in the slaughtered animal. Progeny testing is also indicated for those characteristics which are low in heritability, whereas, performance testing or selection based on the animal's own performance is indicated for characteristics which are moderate to high in heritability. When the heritability of a trait or traits is high enough to warrant selection based on an animal's own performance, the generations can be turned in one-half or less time than when selections are based on a progeny test.

If progeny testing is practiced, one must then decide how many progeny are necessary. Relatively little work has been done to answer these questions. In practice, a minimum of 6 to 8 offspring tested for a minimum of 90 days (postweaning) has somewhat evolved as a compromise for rate of gain and carcass merit.

The first formal sheep performance testing program in the U.S was initiated at Sonora, Texas in 1948 by the Texas Agricultural Experiment Station. This program had as its major objective improvement of wool production through selection of fine-wool breeds or crosses derived from crossing fine-wool breeds.

Similar testing or selection schemes were developed in New Mexico and Australia for improvement of wool production. Summaries from these three programs show that progress can be made in selecting for fleece traits by direct use of performance data without reverting to the progeny test.

How does a performance testing scheme compare with results which might be obtained by visual selection? Australian workers observed that three times the genetic improvement was possible by using flock testing that could be obtained by visual selection. In their analysis, visual appraisal at any age was shown to be only 30 per cent as efficient in

raising wool weights per head and only 45 per cent as efficient in raising money return per head, when compared to flock selection for wool weight.

Ewe Testing

Approximately 80 to 90 per cent of the potential for genetic progress in sheep populations comes from ram selection. This suggests that the commercial producer should buy most of his genetic improvement through his rams.

In commercial programs the genetic superiority of one ewe over another is seldom sufficient to overcome the price disadvantage of ewe meat as compared to lamb meat. The reproductive performance of yearling ewes is much lower than that of mature ewes, and percentages of yearling ewes in flock can be one factor in reduced reproductive performance of the flock. Since the repeatability of lamb weaning weight as a characteristic of the ewe is low and the repeatability of fleece traits is high, one does not have a strong basis for culling ewes once they have been added to the breeding flock.

Ewe testing, including individual ewe performance records, are justified for all purebred flocks, all single-sire flocks, and certain range flocks where replacement ewes are kept.

Ram Test Procedures

Ideally all rams which are to be considered for potential use as sires should be performance tested. Preliminary selection at weaning can be accomplished by culling levels for type of birth, anatomical defects, face cover, wool defects, and so forth. Potential breeding males should be weaned as soon as practical and placed on test. In the case of "ram breeds," especially if progeny testing is a part of the program, they can be placed on test following early weaning at or about 8 weeks of age. In the case of the "ewe breeds" fleece data are important and it is not desirable to start as early as 8 weeks. Animals of this age would be difficult to shear and small differences in body

weight could have a large effect on wool production. The minimum of 90 days test period would be adequate for those breeds in which fleece data are not of interest, but not less than 120 days would be desirable for fleece data. Wool from this period will have limited market value and for this reason the test period should probably be extended at least another 30 days.

The ideal testing scheme for ram breeds would involve a preliminary performance test of weaning lambs followed by the progeny test of the top 10 to 20 per cent based on rate of gain. Final selection of stud rams would be based on rate of gain and carcass merit of the offspring. Once a ram is placed in service he would remain in service until a younger ram demonstrates a superiority. Thus, older stud rams should preferably be retested each year along with the younger stud ram candidate. Because of the cost and time delay involved, the scheme is not likely to receive the producer support necessary for it is to have a significant influence on the industry. A much simpler scheme might be that in which each producer could progeny test his own rams and deliver a designated number of early weaned lambs to a testing station for evaluation or rate of gain and carcass merit.

Farm Flocks and Purebreds

Flock size is one limiting factor to the amount of selection and improvement in many farm purebred flocks. When flock size is such that only a limited number of rams are used, only a small amount of the variation is likely to exist between ram progeny groups. In small flocks the genetic variation among breeding ewes may provide the greatest amount of measurable variation. The use of repeated records on the breeding ewe then becomes of significant importance for greater improvement from selection.

About 150 ewes and 3 rams are the minimum number of animals for a breeding operation. With these number adequate progeny tests may be obtained for the

"stud rams" when entire flock testing is followed. In some areas of the midwest, exchanging of rams appears to be very beneficial.

In larger flocks stratification of flock into production groups and breeding best to best may aid in the improvement from selection. With this program the replacement ewes would come from the top 50 per cent of the flock and the stud replacement rams would be selected from the upper 10 per cent of the flock. Sale rams would be selected from the top 30 to 40 per cent of the flock.

Performance testing and records must be used for selection and culling if improvements in production are to be achieved.

Breeders who use records and improves his sheep must be paid to justify the expense.

More emphasis is needed in educational programs on value of records, and value or lack-of-value of "over-fat rams sold with no regard to production traits."

For small flock owners, exchange of rams may be needed for genetic progress.

Summary

The most efficient production program for the midwestern farm flock states would appear to be the slaughter lamb program. This program should involve the mating of a highly fertile, high wool value crossbred ewe to a "tested" ram who transmits high gaining ability and carcass excellence to his offspring.

There is need for more cooperation among sheepmen in the development of a uniform system of record keeping if we in the U.S. are to locate the genetically superior animals and make use of their germ plasm to improve lamb and wool production.

Bibliography of the Proceedings Genetic Improvement of Wool and Lamb Production Symposium

held at
Texas A&M University
Livestock and Forage Research Center
McGregor, Texas
April 18-19, 1968

Basic Principles of Genetic Improvement for Wool and Lamb Production

G.E. Bradford, Associate Professor,
Animal Genetics, University of California, Davis, California

Discussion

Led by James W. Bassett, Associate Professor, Sheep and Wool Technology, Texas A&M, College Station, Texas

Indicators of Meatiness and Their Inheritance

Zerle L. Carpenter, Associate Professor, Meats Investigations, Texas A&M, College Station, Texas

Discussion

Led by Earl E. Ray, Associate Professor, Meats Technology, New Mexico State University, University Park, New Mexico

Performance Testing and Sire Evaluation

J.M. Shelton, Professor, Animal Genetics, Livestock and Forage Research Center, McGregor, Texas

Discussion

Led by George A. Allen, Jr., Extension Livestock Specialist, Virginia Polytechnic Institute, Blacksburg, Virginia

Practical Methods of Selection and Culling for Lamb and Wool Production

A. Purebred and farm flock Selection
Charles F. Parker, Associate Professor, Animal Genetics, Ohio Agricultural Research Center, Wooster, Ohio

Discussion

Led by Jack L. Ruttle, Assistant Professor, Sheep Physiology, New Mexico State University, University Park, New Mexico

B. Range Selection

R.L. Blackwell, Head, Animal Science Department, Montana State University, Bozeman, Montana

Discussion

Led by James A. Gray, Extension Animal Husbandman, Texas A&M University, San Angelo, Texas

Effective Use of Breeds and Cross-Breeding

J.V. Whiteman, Professor, Animal Genetics, Oklahoma State University, Stillwater, Oklahoma

Discussion

Led by George M. Sidwell, Leader, Sheep Breeding Investigations, USDA Research Center, Beltsville, Maryland

Eliminating Inherited Defects

M.P. Botkin, Professor, Sheep Technology University of Wyoming, Laramie, Wyoming

Discussion

Led by S.K. Ercanbrack, Animal Geneticist, USDA Research Center, Dubois, Idaho

Potential of Imported Breeds

W.J. Boylan, Associate Professor, Animal Breeding and Genetics, University of Minnesota, St. Paul, Minnesota

Discussion

Led by R.C. Carter, Professor, Animal Genetics, Virginia Polytechnic Institute, Blacksburg, Virginia

Breeding Practices for Most Economic Production

Clair E. Terrill, Chief, Sheep and Fur Animal Research Branch, USDA Research Center, Beltsville, Maryland

Historic Document

Reproductive Physiology of Sheep

C. W. Alliston
Animal Sciences Department

The reproductive performance of sheep is influenced by a number of factors which act upon the ewe or the ram or both. The factors that influence the ability to reproduce and the number of offspring include:

Heredity

The number of offspring varies widely. For example, the Merino in certain areas usually gives birth to only one lamb whereas the Finnish Landrace may average 3 to 4 lambs. This trait is usually most directly associated with the number of ova ovulated by the female.

Puberty

The onset of reproductive activity also varies considerably. Published studies have concluded that the lifetime production is greatest if first breeding is at approximately 18 months of age.

Age of Ewe

Although chronological age is not the sole criterion, ewes of 3 to 5 years of age have been demonstrated to maintain reproduction of a flock at the maximum level. However, ewes should be culled more on the basis of physical vigor, condition of teeth, condition of udder, production record, and so forth, than solely upon chronological age.

Nutrition

Efficiency of reproduction is adversely affected by either too high or too low a plane of nutrition. Research reported from Purdue has shown that feeding during gestation at the rate of 80 per cent of the energy level recommended

by the National Research Council (NRC) was satisfactory during the last 105 days of gestation. Seven pounds of low moisture alfalfa silage at a cost of 5.5 cents per day met this requirement. During lactation, addition of 0.75 pound of rolled shelled corn successfully supplied 80 per cent of NRC recommendations at a daily cost of 7.6 cents per ration. Bone meal and trace mineralized salt were added to the ration at the rate of 0.04 pound each.

The term "flushing" is generally used to refer to the practice of increasing the level of nutrition 3 to 4 weeks before breeding to increase the ovulation rate. Although the majority of information indicates that an increase does occur with flushing, a specific recommendation is difficult. Perhaps an increase of 150 to 175 per cent of maintenance requirements is a reasonable level of increase. This might be accomplished either by fresh pasture or by increased feed levels. The greatest increase in ovulation rate has been noted just prior to onset of the breeding season with little or no increase in response to flushing during the peak of the breeding season. Perhaps it should be emphasized that the increased level of nutrition required for "flushing" should not be continued throughout gestation.

Lambing Interval

The 5-month gestation period of the ewe has been the basis of various efforts to accelerate lambing programs to greater than one lamb crop per year. Of such management systems, the most practical appears to be an eight-month lambing interval with lambs born in January, September and May. At Purdue, Rambouillet ewes

have averaged 2.32 lambs born and 1.96 lambs raised yearly over a four year period. This level of production has been possible without use of hormones or other artificial control of reproductive activity.

Effect of Management and Environment

All management practices become more important as increased production is attempted. Among the more obvious management factors are:

- (1) Disease and parasites
- (2) Nutritional status
- (3) Physical condition of rams and ewes.

However, other factors play an important role in the determination of the reproductive efficiency of sheep. These include:

- (1) Season of the year and reproductive activity.

The incidence of estrus in sheep is related to the length of exposure to light with optimal duration of 10-12 hours of daylight. Onset of breeding activity normally occurs during the season of the year when the duration of light is increasing. However, in general, there is little that can be done on a practical basis to alter the duration of exposure to daylight. The physiological action of light is mediated via the endocrine system by production of hormones that terminate anestrus and initiate the breeding season. For this reason, considerable effort has been devoted to studies utilizing exogenous hormones to induce estrus in sheep. Such treatments basically have consisted of administration of a progesterone compound for a period of days (usually 12-16) followed by an injection of a gonadotropin. The gonadotropin is most commonly pregnant mare serum (PMS) given at the rate of 500 to 1,000 international units (I.U.) 24 to 48 hours after the last progesterone injection. Estrus should occur 24 to 48 hours after the PMS injection.

Some studies have included an injection of an estrogen at various times of the treatment.

The advantages of such treatment include:

- (a) Control of breeding date(s)
- (b) Increased incidence of multiple births
- (c) Uniformity of age of lambs with high per cent born in a short interval of time
- (d) Possibility of use of artificial insemination.

The latter advantage would be due to the fact that sufficient numbers of ewes could be inseminated at one time to make it practical for the necessary assistance to be available for the owner not equipped to inseminate his own flock. Unfortunately, techniques for low temperature preservation of ram semen have not been successful. Therefore, the use of stored semen supplies is not possible. However, semen can be diluted, within limits, for breeding larger numbers of ewes than would be possible by natural service. In general, the more successful dilution ratios have not exceeded 10 parts of diluent to 1 part semen. (This is a much lower dilution ratio than is commonly used for the bull.)

Disadvantages include the additional labor involved with the hormone treatment and the cost of the material. The time and labor required can be reduced by use of the oral progesterone compounds that can be added to the ration, by a single implantation with prolonged effectiveness or by the insertion of vaginal sponges. The quantity and timing of hormones administered varies widely with the material used and appears to be the critical factor in such applications. In general, the nearer the natural breeding season, the greater the success with such treatments. Hormonal induction of estrus during the anestrus season continues to be the subject of current research but unfortunately has not reached the

point of having a general commercial application. Only those producers with a good understanding of the factors involved and with adequate management control and flexibility have reason to expect substantial gain from use of hormones at this time.

(2) Season of the year and reproductive efficiency

Male: The ram appears to be one of the most sensitive farm animals to elevated temperature. The term "summer sterility" is frequently used to describe the lowered fertility of rams during periods of summer weather. This lowered fertility is due to decreases in the percent of normal sperm and decreases in the total number of sperm. For most rams, environmental temperatures at or above 90°F. decrease fertility, particularly if humidity is high. It is extremely important to recognize that approximately six weeks minimum is required for fertility to return to normal after exposure to even short periods of elevated temperature. It should also be emphasized that exercise due to any cause will also aggravate the condition by causing an increase in body temperature above that due to the environment alone. The practice of shearing just prior to the breeding season and of allowing ewes to be bred only at night appear to be the most practical answers although artificial cooling by air conditioning equipment has been practiced in some areas.

Female: The reproductive efficiency of the female has also been shown to be affected by elevated temperatures. The nature of the effect includes suppression of estrus, failure of fertilization and embryonic death. Therefore, the practices indicated above for the ram are also applicable to the female. However, the larger number of females makes mechanical air conditioning even less practical. The availability of natural shade becomes particularly desirable and beneficial.

Although the very early stages of gestation (the first one to three days) are of particular concern, birth of light-

weight, weak lambs has been associated with exposure of the female to high temperature during the later stages of gestation.

The factors discussed herein certainly are not intended to include all of the factors that affect reproduction. However, they should serve to emphasize that the total management regime must be carefully considered for optimum reproductive performance, and this becomes particularly important as one enters into programs for accelerated lamb production.

BIBLIOGRAPHY OF THE PROCEEDINGS PHYSIOLOGY OF REPRODUCTION IN SHEEP

held at
Oklahoma State University
Stillwater, Oklahoma
July 26-27, 1968

Factors Affecting Fertility in the Ewe and Ram

C. V. Hulet, Research Physiologist,
U. S. Sheep Experiment Station, Dubois, Idaho

Discussion

Ray H. Dutt, Professor, Physiology of Reproduction, University of Kentucky, Lexington, Kentucky

EFFECT OF Nutrition on Lambing Rates

John E. Butcher, Associate Professor, Beef Cattle and Sheep Nutrition, Utah State University, Logan, Utah

Discussion

A. L. Pope, Professor, Animal Nutrition and Animal Genetics, University of Wisconsin, Madison, Wisconsin

Effect of Management and Environment on Lambing Rates

Leroy H. Boyd, Assistant Professor, Sheep, Mississippi State University, State College, Mississippi

Discussion

J. L. VanHorn, Professor, Animal Production, Sheep, Montana State University, Bozeman, Montana

Effect of Selection on Lambing Rates

Helen Newton Turner, Senior Principle Research Scientist, Animal Genetics Laboratory, CSIRO, Epping, New South Wales, Australia

Discussion

Vern B. Swanson, Associate Professor, Sheep and Wool, Colorado State University, Fort Collins, Colorado

Control of Reproduction With or Without Hormones

W. C. Foote, Associate Professor, Animal Reproduction, Utah State University, Logan, Utah

Discussion

P. J. Dziuk, Associate Professor, Animal Physiology, University of Illinois, Urbana, Illinois

Lambing Out of Season and Accelerated Lambing

J. M. Shelton, Professor, Animal Genetics, Livestock and Forage Research Center, McGregor, Texas

Discussion

Ben B. Doane, Research Assistant, Ruminants, Sheep, University of Illinois, Urbana, Illinois

Artificial Insemination and Preservation of Semen

E. K. Inskeep, Assistant Professor, Animal Science Physiology, West Virginia University, Morgantown, West Virginia

Discussion

Blair E. Terrill, Chief, Sheep and Fur Animal Research Branch, USDA Research Center, Beltsville, Maryland

Early Pregnancy Diagnosis

Ivan Lindahl, Leader, Sheep Nutrition and Management Investigations, USDA Research Center, Beltsville, Maryland

Discussion

C. V. Hulet, Research Physiologist, U. S. Sheep Experiment Station, Dubois, Idaho

Sheep Nutrition

T. W. Perry
Animal Sciences Department

Nutrient Requirements for Maintenance of the Dry Ewe (Non-lactating and first 15 weeks of gestation)

The nutrient requirements of any feeding situation for any species of livestock are four-fold -- energy, protein, minerals and vitamins. Since the ewe is pregnant 150 days and may well nurse her lamb(s) for 180 days, this period largely represents a very short period of non-pregnancy, followed by flushing and then the first 105 days of pregnancy. During this period the ewe should be gaining slightly, perhaps about two ounces per day. It is not desirable that the ewe becomes fat during this period, but rather that she gain back what she lost at the time of lambing and the subsequent lactation.

Ewes ranging from 100 to 160 pounds in weight should consume an average of 2.5 per cent of their liveweight of air-dry feed per day, or from 2.5 to 4 pounds daily. Their total digestible nutrient (TDN) requirement ranges from 1.3 to 1.9 pounds per day for these weights. In other words, their feed should contain approximately 50 per cent TDN during this period. Since good hay contains 50 per cent TDN, it will suffice for the energy requirement in drylot whereas good pasture will supply adequate energy during pasture season.

The ration should contain 8 per cent crude protein during this phase. Since almost any hay or pasture plant will contain in excess of 8 per cent protein, this should not be a problem as long as the TDN requirements are being met.

The minerals of significance during this stage are calcium, phosphorus,

sodium, chlorine, iodine, cobalt and copper. The mineral requirements are met easily by supplying a free choice mineral mixture of 2 parts dicalcium phosphate to 1 part trace mineralized salt, in one compartment of a two-compartment mineral box. Place plain salt in the other compartment.

It is doubtful if any vitamin will cause problems during this phase. The carotene of pasture grasses or of green hays, if in drylot, will supply a source of vitamin A and exposure to sunlight will provide vitamin D.

Nutrient Requirements of the Ewe During Gestation (Last Six Weeks)

To provide adequate energy for the production of strong lambs and a good milk supply, the energy requirements for the last 6 weeks of gestation are higher. First, the ewe is somewhat heavier now than she was at the start of the dry period. Furthermore, the rate of gain should be increased to nearly one-half pound per day during this, the final stage of pregnancy. She should be given from 3 to 3.8 per cent of her liveweight as air-dry feed, which will be from 3 to 5 pounds per day depending on her size. The TDN requirement during this period is near 2.5 pounds per day. In order to supply this energy level, ewes in drylot may well require one-half pound of corn per head daily, in addition to their hay. If on good pasture, their TDN requirement will probably be met.

Protein requirement is increased during this stage to nearly one-third pound per day. Since average alfalfa hay contains 15 per cent protein, a little over 2 pounds alfalfa hay would provide one-third pound of protein. Good pasture

will supply adequate protein.

Minerals can be supplied by the free-choice mineral program as prescribed for the dry ewe.

Ewes consuming green feeds or limited yellow corn should have no vitamin A problems. If they get into the sunshine, vitamin D should be no problem. If limited corn is being fed, vitamin E should not be a problem.

Nutrient Requirements for the Ewe During Lactation

Naturally, the specific requirements for lactation will vary in proportion to the amount of milk produced. It should be realized and expected that the ewe which is lactating will lose weight during this period, no matter how well she is fed. Her air-dry feed requirement during this period (for a 100 to 160 pound ewe) will be between 4.5 and 6 pounds depending on her size. Her TDN requirements will be from 2.7 to 3.1 pounds per day. This then will require a higher energy ration. Unless the ewe has access to very nutritious pasture, from one-half to one pound of grain should be fed per head daily during the first 8 to 10 weeks of lactation.

Protein requirements will increase in a parallel manner to the energy requirements during this phase. The lactating ewe will need between one-third and one-half pound of crude protein per day. Unless she is getting a legume roughage, she should get from .1 to .2 pound of soybean meal per head daily, in addition to her corn.

Although the calcium and phosphorus requirements will increase drastically with the onset of lactation, these needs will be met by the feed plus the free-choice mineral program suggested for the dry ewe.

Vitamin requirements for lactation are similar to those listed for the last six weeks of gestation except that increased levels of vitamin E in the diet of the lactating ewe may be of assistance in lowering the incidence of stiff lamb

disease in her suckling lambs. A good feed source of vitamin E for the ewe is the germ of grains especially that of wheat. Exposure to sunlight probably will supply adequate vitamin D, and use of bright green forage or of yellow corn probably will supply adequate carotene from which the ewe can synthesize vitamin A.

Nutrition of Early-Weaned and Creep-Fed Lambs

Early weaning can be defined as the removal of the lamb from its milk supply before the normal weaning age of 120 days is reached. Very early weaning can be accomplished using essentially milk replacer type formulas such as are used for pigs or calves. However, few researchers have reported the weaning of lambs at earlier than 6 to 8 weeks without reduction in performance. However, this does not rule out its potential after additional research has been conducted. The National Research Council does not list the nutritional requirements for a lamb less than 50 pounds liveweight, indicating that very little research data are available in this area.

Lambs of less than 4 weeks of age are essentially non-ruminants - possibly this status may extend to even a later age. Therefore, lambs weaned up to 6 or 8 weeks of age can be fed a typical 16 per cent protein fortified corn-soy swine ration. The inclusion of 10 per cent cane sugar will enhance the acceptance of this ration by lambs. It should be pelleted into a quarter-inch pellet. After such lambs reach 50 or 60 pounds, they should be converted to typical feeder lamb rations containing more roughage or else rumen parakeratosis problems will be encountered.

The 60 pound lamb may be fed out to market finish by one of several programs. One of the most common is the feeding of whole shelled corn - usually from 1.5 to 1.8 pound per day, plus ad lib hay (1.7 to 2.0 pounds per day), and free-choice minerals such as were listed for the dry ewe. If the hay is high quality alfalfa, possibly no additional protein will be needed. However, if it is not

legume hay, 0.2 pound soybean meal per head daily, should be fed.

Another method of feeding finishing lambs is use of the Purdue 58 pellet. Lambs will gain rapidly and efficiently on this pellet, and furthermore, they can be fed a full feed from the first without fear of "overeating" disease or of other digestive disorders. Many modifications of the Purdue 58 pellet have been researched, but no modification has resulted in improved performance. The formula for the Purdue 58 pellet with a 5 per cent molasses modification is given in Table 1.

Table 1. *Purdue 58 Pellet with 5 per cent molasses*

Ingredient	%
Ground corn cobs	39.5
Dehydrated alfalfa meal (17%)	20.0
Ground yellow corn	27.0
Cane molasses	5.0
Soybean meal	7.0
Iodized salt <u>1/</u>	0.5
Steamed bonemeal	1.0
Vitamins A and D <u>2/</u>	+
	100.0

1/ One ounce cobalt carbonate per 100 pounds iodized salt.

2/ 1700 units vitamin A and 212 units vitamin D per pound ration.

Use of Feed Additives for Lambs

Generally, no feed additives are recommended for lamb feeding. Although a whole host of additives have been tested, none known today are too desirable. Diethylstilbestrol (DES) will produce dramatic gain responses in lambs, but the side effects of lowered carcass quality increased incidence of prolapsed rectum and/or vagina, and the tightening of the pelt to the carcass, make its use questionable.

Antibiotics have been credited with aiding in combating "overeating" disease, but as yet, there are divided opinions on the subject.

Other additives which have been researched and have not shown consistent benefits include tranquilizers, thyroid inhibiting and thyroid stimulating products, enzymes and arsenicals.

BIBLIOGRAPHY OF THE PROCEEDINGS SHEEP NUTRITION AND FEEDING SYMPOSIUM

held at
Iowa State University
Ames, Iowa
October 8-9, 1968

Nutrient Requirements For the Maintenance of the Dry Ewe

W. C. Weir, Professor, Nutrition, Ruminants, Sheep, Animal Husbandry Department, University of California, Davis, California

Nutrient Requirement of the Ewe During Gestation

E. E. Hatfield, Associate Professor, Ruminants, Animal Science Department, University of Illinois, Urbana, Illinois

The Nutritional Requirements of Lactating Ewes

D. E. Hogue, Associate Professor, Animal Science Department, Cornell University, Ithaca, New York

Nutrition and Wool Production

James W. Oxley, Head, Animal Science Department, Colorado State University, Fort Collins, Colorado

Discussion

A. L. Pope, Professor, Animal Nutrition, Meat and Animal Science Department, University of Wisconsin, Madison, Wisconsin

Growth and Development of the Young Lamb for Maximum Response upon Early Weaning

Hudson A. Glimp, Chairman, Sheep Section, U. S. Meat Animal Research Center, Clay Center, Nebraska

Growing and Finishing Feedlot Lambs

C. S. Menzies, Associate Professor, Sheep Research, Animal Husbandry Department, Kansas State University, Manhattan, Kansas

California Pasture Lamb Feeding

G. M. Spurlock Extension Animal Scientist, Animal Husbandry Department, University of California, Davis, California

Discussion

Tom W. Wickersham, Extension Livestock Specialist, Department of Animal Science, Iowa State University, Ames, Iowa

Less Expensive Proteins (nitrogen) for Sheep Diets

U. S. Garrigus, Professor, Animal Nutrition, Ruminants, Animal Science Dept., University of Illinois, Urbana, Illinois

Feeding Systems for Sheep Under Farm Flock Conditions

R. M. Jordan, Professor, Ruminant Nutrition and Management, Animal Husbandry Department, University of Minnesota, St. Paul, Minnesota

Feeding Systems for Sheep Under Range Conditions

C. Wayne Cook, Head, Department of Range Science, Colorado State University, Fort Collins, Colorado

Factors Affecting Forage Utilization in Sheep Rations

F. C. Hinds, Assistant Professor, Ruminants, Animal Science Department, University of Illinois, Urbana, Illinois

Effect of Feed Processing in Lamb Rations

A. L. Esplin, Professor, Sheep, Animal Science Dept., Colorado State University, Ft. Collins, Colorado

Use of Feed Additives for Lambs

E. A. Ott, Manager, Horse and Sheep Research, Ralston Purina Co., Checkerboard Square, St. Louis, Missouri

Common Metabolic Disorders -- Nutritional Deficiencies and Toxicity Problems in Sheep

J. H. Cline, Professor, Nutrition, Animal Science Department, Ohio State University, Columbus, Ohio

Discussion

R. J. Emerick, Professor, Biochemistry Station, South Dakota State University, Brookings, South Dakota

Historic

Sheep Diseases and Health

K. M. Weinland
Extension Veterinarian

Disease Problems of Feedlot Lambs

Feeding lambs is a seasonal occupation. Lambs are weaned in the fall of the year and transported to feedlot areas weighing an average of 70 pounds. They are fed until they weigh between 105-115 pounds. This usually requires a feeding period of between 60 to 120 days.

No matter what method of feeding is followed, certain conditions are common to all methods. Such conditions often predispose to various diseases. Most of the important diseases of feeder lambs are related to either recent weaning and transportation (stress), changes of feed (nutritional), and crowding (bacterial and viral).

ENTEROTOXEMIA

Common Name: Overeating Disease
Pulpy Kidney

Occurrence: Enterotoxemia affects sheep of all ages from one week to several years of age. Two peaks of incidence are recognized. The first corresponds largely to the grazing period when single lambs nurse ewes with an abundant milk supply while grazing on improved pastures. The second peak corresponds with the fattening period when the lamb is usually 6 months to one year of age.

Enterotoxemia is one of the most common causes of death in feedlot lambs. In "explosive" outbreaks losses may range from 10 to 40 per cent. In unvaccinated feedlot lambs one can expect a minimum of 1 per cent of the lambs to die from this disease with an average death loss of between 2 - 2.5 per cent.

Nature of the Disease: The disease is caused by a germ known as *Clostridium*

Perfringens Type D. It is normally present in the lower bowel of many sheep. Under circumstances brought about by heavy feeding, it grows rapidly, enters the small bowel, and produces a powerful poison (toxin) which is absorbed through the intestinal wall, causing death in a few hours. In many instances deaths occur so quickly that owners do not observe sick animals.

Predisposing Factors:

- (1) Sudden change of feed
- (2) Too high an energy diet
- (3) Irregular feeding
- (4) Increasing the amount of concentration too rapidly
- (5) Heavy parasite burden
- (6) Devitalization of the intestinal tract due to the presence of large amounts of undigested or partially digested food in the gut increases toxin absorption
- (7) A lack of natural or artificial immunity

Symptoms: Deaths from enterotoxemia usually occur suddenly, even though some animals may be observed sick for several hours or even a day or longer before they die. Feedlot lambs frequently exhibit nervous symptoms, the head being drawn backwards, and the animal showing convulsive movements and frothing at the mouth. Sometimes the animal appears to be in a coma: death taking place quietly. Diarrhea may be present shortly before death.

While the symptoms described above are suggestive for enterotoxemia, they may be seen in other diseases of feedlot lambs characterized by sudden death.

Diagnosis: A diagnosis of enterotoxemia is suggested by the sudden death of feedlot lambs. This diagnosis can be confirmed by laboratory tests. It is wise to seek the counsel of a veterinarian to help in establishing a diagnosis and to outline control measures.

Prevention: There is no satisfactory treatment for affected animals. Therefore, all emphasis should be placed on prevention.

Preventions by management includes:

(1) Make the adjustment from range conditions to feedlot conditions gradually. Place lambs on either alfalfa hay or prairie hay first and gradually accustom to concentrate.

(2) Check lambs for parasites and worm as recommended prior to vaccination because a burden of parasites interferes with antibody production from the vaccines.

(3) Have ample amount of feed in front of lambs at all times.

(4) The use of antibiotics in the feed (10 milligrams/pound of feed) may reduce some of the losses due to enterotoxemia but will not always prevent the disease.

Prevention by vaccination includes:

(1) If the lambs are in good condition and are not wet, vaccinate the lambs soon after arrival in the feedlot with either a bacterin or toxoid. Allow at least 10 days after vaccination for immunity to develop.

(2) Under certain conditions, revaccination with the bacterin or toxoid is required (booster dose) at a later date (4-8 weeks later).

In case of explosive outbreaks late in the feeding period, several procedures may be followed:

(1) Reduce amount of concentrate by 50 per cent for 1 week or longer, and gradually increase the amount of concentrate to full feed.

(2) Sort lambs into two groups. The ones close to marketing should be shipped as soon as possible. The other group should be vaccinated with the bacterin or toxoid and gradually returned to full feed.

(3) Consider the use of Type D anti-toxin to immediately stop the loss. The immunity will be temporary (2-3 weeks) but losses will ease. After the worst is over, you may secure a long-lasting immunity by vaccinating or giving a booster dose of bacterin or toxoid. The use of serum to stop an outbreak of enterotoxemia may be expensive. A veterinarian should be consulted for the proper program to follow for maximum control.

Summary: Enterotoxemia is the most important and common feedlot disease problem.

Common Name: Salmonellosis

Occurrence: Salmonellosis is not a common disease of feedlot lambs and occurs only sporadically. However, when it does occur, it may be one of the most serious of all feedlot diseases of lambs to control.

Predisposing Factors: Many outbreaks have followed delays in shipping. It is thought that irregularity of feeding which may be associated with transportation may be the chief predisposing factor.

Herd Incidence: It is usually about 5 per cent, but can go up to 25 per cent.

Mortality: 10 per cent of lambs may die from paratyphoid dysentery.

Clinical Signs: Salmonellosis may start by sudden death of a few lambs a

week or ten days following entry of the lambs into the feedlot. Many die within two to five days after onset of signs. Affected lambs exhibit semifluidity of stools which has a characteristic greenish color and may contain blood. Loss of weight and marked dehydration is observed. The temperature of the affected lamb is elevated to 105°-106°. About 10 per cent of clinically recovered lambs fail to make normal rates of gain in body weight.

Note: This disease is transmissible to man. Every precaution should be taken to avoid contamination of foods for human consumption.

CONTAGIOUS ECTHYMA

Common Names: Sore Mouth, Contagious Pustular Dermatitis, Scabby Mouth

Occurrence: Sore mouth is a common disease of lambs all over the United States as well as many foreign countries. While the morbidity can reach nearly 100 per cent of a group of lambs, the mortality is negligible. This disease occurs most commonly in late summer and fall on pasture and later in the feedlots.

Clinical Signs: While all ages of sheep can become infected, sore mouth of sheep is usually limited to lambs. The incubation period depends upon the amount of virus present and varies from eight to ten days. Lesions begin as small red spots at the corners of the lips. Sometimes the nostrils, eyelids, and mouth are involved. Crustations last one to three weeks with spontaneous healing. During the period when the scabs are prominent on the lips, eating is painful. Loss of body weight is noticeable. Occasionally a lamb dies either from starvation or secondary pneumonia. Nursing lambs may spread the infection to the teats of ewes. Some lambs will develop lesions on the feet and become lame.

Diagnosis: The ecthyma virus produces a characteristic type of lesion.

Immunity: Sheep that have recovered from a natural attack are highly resistant to reinfection.

Treatment and Prophylaxis: Medicinal preparations have not proven too effective in the treatment of this disease. Combinations of iodine and glycerine rubbed onto the lesion following removal of the scab is still a popular treatment. Commercially available vaccines can be used to treat lambs on infected premises or in feedlots. Vaccination of lambs at docking time is recommended as a good management procedure.

Note: Pneumonia is covered under common respiratory problems.

Internal Parasites

Internal parasites are probably the most important cause of losses in Indiana sheep. Losses caused by these parasites include decreased gains and death. It is impossible to conduct a highly profitable sheep enterprise without adequately controlling them.

Parasites

Many different gastrointestinal parasites infect Indiana sheep. These vary in size from 1.5 inches in length and as thick as a pencil lead to so small they cannot easily be seen without a microscope. Some of the most important internal parasites of Indiana sheep are: large or twisted stomach worm (*Haemonchus contortus*) which lives in the fourth stomach, medium or brown stomach worm (*Ostertagia circumcincta*) which lives in the fourth stomach, small stomach worm (*Trichostrongylus axei*) which lives in the fourth stomach, bankrupt worm (*Trichostrongylus colubriformis*) which lives in the small intestine, thread-necked strongyle (*Nematodirus spathiger*) which lives in the small intestine, Cooper's worm (*Cooperia curticei*) which lives in the small intestine, nodular worm (*Oseo-phagostomum columbianum*) which lives in the large intestine, and broad sheep tapeworm (*Moniezia expansa*) which lives

in the small intestine. For further information on internal parasites in sheep, ask for VY-27 at your county Extension office.

Common Respiratory Problems of Sheep

ACUTE PNEUMONIA

Newborn lambs are immediately subjected to external factors which tend to overwhelm their resistance. These factors include pathogenic micro-organisms both viral and bacterial plus stress.

The causative factors of lamb pneumonia seem to parallel those of shipping fever in calves. Control of acute pneumonia should be directed toward husbandry practices known to minimize outbreaks:

- (1) When shed lambing, keep the premises clean and dry as possible. The addition of air-slaked lime or superphosphate to well-cleaned lambing pens will minimize odors and moisture.
- (2) The nutritional status of the ewe is important for vigorous lambs.
- (3) Minimize the stress factors as much as possible. Provide shelter against storms and shade from hot summer sun. Feed at regular intervals and avoid abrupt changes of diet. Don't overcrowd during shipment, and avoid long hauls without rest.

Treatment of acute pneumonia is variable and should conform to the type of operation involved. Before attempting treatment of an outbreak of any consequence, it is necessary to establish a reliable diagnosis based upon clinical symptoms and autopsy findings.

The broad spectrum antibiotics are usually helpful against more acute pneumonias. Antibiotics are ineffective against virus diseases. They can, however, assist in treating virus diseases by keeping down secondary bacterial pathogens.

Clinically sick sheep should be placed in a hospital pen. This pen should be clean, well-bedded, and offer protection from extremes of weather. A nutritious but bland diet and adequate water should be available at all times.

PURULENT PNEUMONIA

The presence of abscesses in the lungs of sheep is quite common. They may occur as an aftermath of acute pneumonia, or may spread to lung tissue from abscesses elsewhere on the animal. These are observed frequently at diagnostic laboratories and are considered to be of considerable economic importance.

Sheep which discharge pus contaminate the premises and are responsible for spreading abscesses throughout the flock. Procedures such as shearing or marking cause breaks in the skin and allow entrance of pus-forming bacteria. Pastures in late summer, when bearded grasses are ripe, contribute skin punctures and an avenue for bacteria to enter the body.

The following are suggestions for minimizing abscesses in sheep:

- (1) Shear young sheep first. Have several sets of clipper blades and change blades every sixth sheep or after a sheep with an obvious abscess. Keep blades in disinfectant when not in use.
- (2) Eliminate old non-productive sheep, as they are often disease-spreaders.
- (3) If abscesses are treated, isolate the animals involved for one week or until the wound has healed and is no longer draining pus.
- (4) Treat the navel stump of newborn lambs with tincture of iodine.
- (5) Prevent rams from fighting as much as possible.

(6) Control head grubs (*Oestrus ovis*) by treating with organic phosphates in the fall. Sinuses and nasal areas often abscess and contribute to the lung problem.

VERMINOUS PNEUMONIA

The lungworm (*Dictyocaulis filaria*) is fairly common and contributes to pneumonia, especially in lambs in their first summer of life. These parasites spend their adult life in the terminal branches of the bronchial tree. The parasite plus exudate causes obstruction of the bronchioles. Secondary bacterial pneumonia may appear and is frequently fatal.

NUTRITIONAL PNEUMONITIS

We ordinarily think of white muscle disease (WMD) as affecting skeletal muscle and causing symptoms of progressive paralysis. Muscles of the heart, diaphragm, tongue and esophagus are also commonly affected. When extensive damage to heart muscle occurs, sudden death is likely. More often we observe a slow progressive cardiac failure. This leads to passive lung edema and slow death from suffocation.

The nutritional background three months prior to lambing will determine the incidence of WMD in a lamb crop. Extensive losses can be observed the first few days following birth. The lambs are born with this condition, which lowers their resistance and makes them more susceptible to scours and acute pneumonia. To avoid considerable economic loss from this condition, it is necessary to inject ewes with selenium prior to lambing. The commercially available selenium-tocophoral products have proven quite satisfactory for prevention of WMD. When diagnosed under field conditions, WMD is considered to be a herd problem, and all lambs are treated at birth. When experience indicates WMD is an annual problem, best results are obtained by injecting ewes from 1 to 4 weeks prior to lambing.

UPPER RESPIRATORY PROBLEMS

The major upper respiratory problem in sheep is caused by larvae of the nasal botfly (*Oestrus ovis*). The distribution of this fly appears to be worldwide wherever sheep are raised. They interfere with grazing, cause reduced weight gains and loss of wool production. In addition to the nuisance, the larvae develop in the nostrils and sinuses. The organophosphate chemicals are quite effective in eliminating the larvae and breaking the life cycle of this fly. These chemicals should be used in the fall after the adult flies have become inactive.

Diseases Affecting the Reproductive Capacity of the Ewe

VIBRIOSIS

Vibriosis of sheep is caused by the bacteria *Vibrio fetus*. The organism differs culturally and antigenically from the *Vibrio fetus* which causes infectious infertility in cattle.

Symptoms: The most characteristic symptoms of vibriosis in sheep is abortion during the last six weeks of pregnancy or the birth of dead or weak full-term lambs. In most cases the ewe will show few if any symptoms before aborting. After abortion there is usually a brownish, foul-smelling vaginal discharge for a few days. In some outbreaks there are a few ewe deaths due to uterine infections, but in most cases the fetal membranes are expelled with or soon after the fetus and the ewe will appear quite normal. In many cases the ewe will not even go off feed. Aborting ewes usually recover completely in a short time and will be immune to further abortions due to vibriosis. The abortion rate varies with outbreak from 10 per cent to over 70 per cent.

The fetus often is aborted encased in the placental membranes. The fetus often shows an accumulation of bloody fluid in the abdominal cavity producing a "mushy" bloated appearance.

Diagnosis: The diagnosis of ovine vibriosis is a laboratory procedure involving isolation or demonstration of the *Vibrio fetus* organism from the aborted fetus, placenta, or from the vaginal discharge of the ewe. A tentative diagnosis can be made from the history of the outbreak and appearance of the aborted fetus.

Transmission: Vibriosis remains from year to year in a few carrier ewes. These ewes shed the organism in their feces, contaminating the feed and water. If susceptible ewes consume this feed or water, infection results. Once a few ewes abort the area becomes grossly contaminated as the aborted fetuses, placentas and discharges contain many organisms. If many susceptible ewes are present, an "abortion storm" results.

Control: Ewes that have aborted from vibriosis are immune to further infection from vibriosis. Ewes which are in a flock during a vibriosis outbreak appear to be immune although they themselves have not aborted.

Commercial vaccines against ovine vibriosis are currently available which if properly administered give good protection. It is recommended that the vaccine be administered at breeding time. Usually one injection is given to the ewes just prior to breeding and a second vaccination 3 to 4 weeks later.

Since normal lambing ewes in flocks having undergone a vibriosis epizootic are apparently immune as well as those ewes aborting from vibriosis, it is usually recommended that only replacement ewes be immunized.

During and prior to lambing sanitation is very important. Lambing grounds should be roomy, well-drained and easy to clean. Feeding should be from feed bunks rather than the ground. The feed and water must be kept clean and free from contamination.

The first few abortions are probably the most important ones. The aborted fetuses and placentas should be submitted to a laboratory for prompt diagnosis. The aborting ewes should be isolated from the

rest of the band; all aborted fetuses and membranes should be burned or buried.

Control of vibriosis in sheep involves sound management practices, strict sanitation, early diagnosis and proper vaccination programs.

ENZOOTIC ABORTION OF EWES

This disease is characterized by premature births and abortions. The percentage of abortions is usually 1-2 per cent but has been reported as high as 30 per cent. This disease appears to be very widespread and quite possibly accounts for major economic losses to the sheep industry.

Symptoms: Clinically this disease appears quite similar to vibriosis with abortions occurring late in pregnancy or the birth of full-term dead or weak lambs that die soon after birth. Ewes appear somewhat sick and depressed for a few days before and after they abort. The placental membranes are quite often retained for a few days following abortion, and there is a brownish vaginal discharge.

Transmission: The possible spread of this infection is assumed to be as follows: A ewe becomes infected when exposed to aborting ewes, and the organism persists as a latent infection. When the ewe next becomes pregnant the organism infects the placenta, probably about the middle of gestation. The placenta becomes infected, then the fetus, and abortion results.

Control: A vaccine has been commercially available in Great Britain for many years and appears to give good protection. This vaccine has been used experimentally in the United States with similar results.

As in the case of vibriosis the aborting ewe sheds many organisms which can contaminate the feed and water supply; therefore, strict sanitation is very important. Aborting ewes should be isolated. Often ewes will show a brownish or bloody discharge for a day or two before aborting. If noticed, these ewes should also be removed from the flock.

TOXOPLASMOSIS

Toxoplasmosis is a disease caused by infection with the protozoan parasite *Toxoplasma gondii*. It occurs in man and several species of mammals and birds. In most species, it causes encephalitis, pneumonitis and myositis, but in sheep it is a cause of abortion.

Symptoms: Many sheep apparently carry the disease organism without exhibiting any symptoms. Abortions usually occur during the last month of pregnancy; full-term lambs may be born dead or weak. Retained placentas have been reported in some outbreaks, and abortion rates as high as 50 per cent have been recorded.

MASTITIS

This discussion is limited to mastitis of ewes caused by a *Pasteurella*. In this type of mastitis, gangrene develops quite rapidly hence the common name "blue bag."

Symptoms: In *Pasteurella* mastitis the disease develops rapidly; the ewes become quite sick and depressed with a high fever. The infection is usually limited to one-half of the udder. As the infection progresses, half of the udder becomes very hard, reddened and swollen. The pain from the swollen udder will quite often cause the ewe to limp in an effort to avoid hitting the udder with the rear leg. Within a day or two the udder becomes very hard, gangrene often develops with a characteristic blue color and coldness of the udder. Death occurs in about 25 per cent of the affected ewes in about four or five days. In ewes that recover, the affected half of the udder remains nonfunctional. If the udder has become gangrenous and the ewe survives, there is a sloughing of the affected portion.

Transmission: The source of the infection is not determined. *Pasteurella hemolytica* is a common cause of pneumonia in young lambs and is possibly present in normal sheep.

Control: Experiments with *Pasteurella* vaccines against mastitis have not been satisfactory.

Diseases Affecting the Reproductive Capacity of the Ram

EPIDIDYMITIS AND ORCHITIS

Symptoms: Symptoms vary with the causative agent, but generally speaking, one simply finds development of a lump in one or both epididymides. These lesions most commonly affect the tails of the epididymides and may be detected by palpation of the scrotal contents; however a lesion may also be found in the head or body of the epididymides.

Effect on Fertility: In a detailed study of 29 rams having epididymitis, 50 per cent of the rams had semen of inferior quality, and 25 per cent had semen of only average quality.

Rams with both sides affected with epididymitis showed from 0 - 44 per cent conception, whereas, when only one side was affected, up to 78 per cent conception rate was obtained when the rams were exposed to ewes.

Diagnosis: There are three methods of diagnosis:

- (1) Manual palpation
- (2) Bacterial examination of the semen
- (3) Serological tests

SHEATH ROT OR POSTHITIS

This condition is found extensively throughout the Western United States, New Zealand and Australia.

The cause of sheath rot has been shown to be a bacteria and urea in the urine. The bacteria seems to have the power to hydrolyze urea with the production of ammonia which causes the irritation of the prepuce. The bacteria can survive in the soil, especially during cooler months, and from here infect

other rams. This organism could be transmitted from one class of stock to another.

Once the animal develops the external lesion (raw area around the orifice of the prepuce) the skin becomes swollen and internal lesions may develop. Extension of the external lesion internally may lead to occlusion of the orifice and accumulation of urine and pus in the sheath.

There is no known prevention for this type of posthitis. A number of treatments have been tried by different ram raisers, but one part copper sulfate in eight parts vaseline seems to be as effective as any. Australian workers report that a 20 per cent alcohol solution of cetrimide gave better results than copper sulfate.

ULCERATIVE DERMATOSIS OR LIP AND LEG DISEASE

This is a contagious disease of sheep that has been reported in the United States, England, France and Germany.

The condition has been shown to be caused by a virus. The question of the similarity of the virus of ulcerative dermatosis and contagious ecthyma is not clearly defined.

This condition is spread by direct contact, but requires a break in the skin to enter. Lesions of the prepuce, penis and vulva, occur as a result of transmission by breeding.

Symptoms: In ulcerative dermatosis, there are raw granulating ulcers on the skin of the lips, legs, feet and genital organs. In early cases in rams, one might find a small ulcerative lesion on the prepuce. At this stage, ulcerative dermatosis is impossible to differentiate from non-contagious posthitis. For this reason, rams showing posthitis at ram sales are rejected.

As the condition spreads, the penis becomes involved and the ram may be unable to breed because of the swelling and secondary infection. Frequently, you will notice a ram limping and find a raw

ulcerative lesion between the toes. Upon further examination, you will find sheath lesions or even lesions on the penis. Sometimes, you will see a ram with a scab above the lip and think you might have missed vaccinating this buck for sore mouth, but on further examination, find the sheath and penis involved.

When infected rams are detected before breeding, they should be isolated and not used for breeding, because they can spread the infection to the ewes venereally.

Sheep are susceptible to repeated infection; therefore, they apparently aren't able to develop an immunity for any duration.

Common Metabolic Diseases Affecting Sheep

The major metabolic diseases affecting sheep are hypomagnesemia, hypocalcemia, and pregnancy toxemia (Ketosis). These diseases occur wherever sheep are raised. While they have been occurring for some time, significant advances in diagnosis and classification did not begin to occur until about the 1920's to 1940's. Furthermore, it would seem that the actual incidence of the metabolic diseases increased with the introduction of more intensive husbandry and management systems. Ketosis is by far the most commonly occurring metabolic disease and causes the greatest economic losses.

Metabolic diseases involve disturbances in the mineral or energy metabolism of the body and alterations in the blood concentrations of these metabolites.

HYPOMAGNESEMIA

Hypomagnesemia, sometimes referred to as grass tetany or grass staggers, is somewhat better known in cattle than in sheep. It usually occurs in the spring when lactating ewes are turned out on rapidly growing or lush pastures especially if recently fertilized. It also can occur in animal's grazing on winter wheat or oats. Hypomagnesemia is characterized

by a low blood magnesium content but a low blood calcium also may be present. It usually is an acute condition with death occurring due to muscular spasms or tetany within only a few hours after being noticeably ill.

A low magnesium content of the feed can be a factor in the development of hypomagnesemia, but the disease can still occur even though no magnesium deficiency exists. Magnesium is stored in bone to some extent but this magnesium evidently cannot be withdrawn rapidly enough by the body in order to meet sudden or high requirements. Recent studies have suggested that the incidence of hypomagnesemia is increased if: (1) the bodily need for magnesium is increased such as during pregnancy, lactation, or stresses such as short periods of starvation, or (2) the amount of magnesium actually absorbed or available to the body is decreased.

Clinical Signs and Lesions: The clinical signs of hypomagnesemic tetany in sheep usually occur suddenly, and usually more than one animal in the flock is affected. Deaths occur within a few hours or at the very most within one day. Affected sheep become separated from the flock and have muscular tremors, nervous excitement, a staggered or stiff gait and finally go down into spasms and convulsions. Lactating and older ewes are most often affected, but this does not rule out its occurrence in pregnant or barren ewes.

No consistent lesions or gross abnormalities have been found on post-mortem examination.

Prevention: When sheep are turned out to graze on early growth of cereal grasses or on heavily fertilized pastures, magnesium supplements should be given. This has been done in a number of different ways with apparent success in most cases. Recommendations include .25 ounce of magnesium oxide per head daily or .5 ounce every second day. It should be mixed with oats, or if in pellet form, it can be mixed with bran or molasses. Calcium supplementation is usually

unnecessary and possibly not helpful. Prevention of tetany has been reported by feeding a mineral mixture containing 16 per cent magnesium oxide.

Another general prevention measure is to feed hay at night and allow the ewes to graze on highly improved pastures only during the day. Ewes subject to tetany should always be kept under close observation.

HYPOCALCEMIA

Hypocalcemia, also called milk fever or lambing sickness, has been more widely recognized in cattle than in sheep. It is characterized by low blood calcium but other blood constituents such as magnesium and phosphorus occasionally are altered as well. A deficiency of calcium in the feed is not necessarily present. The disease is most prevalent in ewes in late pregnancy, but it sometimes occurs during the first few weeks of lactation.

Etiology: The four basic predisposing or causative factors for the disease in ewes are: (1) a sudden stopping of feeding, (2) a change of feed, (3) grazing on plants high in oxalate, and (4) feeding for an extended period on low-calcium rations such as cereal grains or chaff under drought conditions. Pregnant or early lactating ewes are the most susceptible especially under stress conditions such as being driven or yarded for shearing.

Clinical Signs and Lesions: The clinical signs of hypocalcemia develop suddenly and there is about a 90 per cent mortality with death occurring from 4 hours to 1 or 2 days. Depending on how often the sheep are seen, they may be found either dead or unconscious or showing typical signs of tremors, a stiff or stilted gait, depression, and later, an inability to stand. When down, the sheep is often found lying on its sternum, the hind legs extended out behind and the head either stretched out forward or turned around onto the flank.

No characteristic lesions have been found on post-mortem examination although the rumen is more filled with ingesta than in the case of pregnancy toxemia. Bloating is common.

Treatment: Most individual cases respond to intravenous or subcutaneous injections of calcium salts, and recovery is complete within 1 to 2 hours. The incorporation of magnesium and dextrose in the same solution might be of additional aid for prompt recovery. The treatment may be repeated after several hours or on the following day.

Prevention: Good management and proper nutrition do much to prevent the occurrence of this disease. All periods of fasting, such as caused by driving, yarding, or shearing, should be reduced to a minimum. Pregnant ewes should never be starved overnight if at all possible. Ewes grazing on fresh green crops should be watched closely and sudden changes in feed should be avoided. Calcium supplementation is indicated if the feed is known to be calcium-deficient. This can be done using a lick containing 2 parts limestone to 1 part salt. During drought conditions when sheep are fed almost exclusively on wheat or other cereal grains which are low in calcium, the addition of 1 per cent ground limestone to the grain is recommended.

PREGNANCY TOXEMIA (KETOSIS)

Pregnancy toxemia in sheep has also been called ketosis, lambing sickness, twin-lamb disease, and domsiekte. It occurs in all parts of the world and is a highly fatal disease occurring only during the last month of pregnancy. Death occurs in 2 to 10 days in about 80 per cent of the cases. Economic losses have been considerable, and it is the most commonly occurring metabolic disease of sheep.

Etiology: It is generally accepted that the basic cause of pregnancy toxemia is a disturbance of carbohydrate or sugar metabolism which is associated with,

or results in, hypoglycemia, ketosis, decreased liver glycogen, and fatty infiltration of the liver.

The factors affecting the onset and progress of this disturbed metabolism may be grouped into three categories: (1) nutrition and management, (2) metabolism, and (3) endocrine or hormonal secretions.

Nutrition and Management: Pregnancy toxemia can be classified and sometimes even experimentally induced by (1) a chronic undernourishment or underfeeding during pregnancy and (2) a short but nearly complete fast in well-nourished sheep in association with environmental or psychological stress. This includes climatic stresses such as heavy snow or rain, and psychological stresses such as transport on foot or by truck, or with other stresses such as an outbreak of a minor disease. In practice, undernutrition is probably the most common factor in causing susceptibility but stress or a short period of going without feed frequently triggers the initiation of the disease.

One major factor in the nutrition of the pregnant ewe is that of the unborn lamb. The gestation period of the ewe is short compared to many animals, and the fetal demand for nutrients and glucose is at its greatest during the last 2 months of pregnancy. Figure 1 shows that about 80 per cent of the growth of the fetus occurs during the last 6 weeks of pregnancy; and if twins are present, the increase in total weight is considerable. The total metabolic rate increases by at least 50 per cent during late pregnancy. It has been shown that late-pregnant ewes require about 50 per cent more feed if bearing a single lamb and about 75 per cent if carrying twins. This amount of feed, however, sometimes exceeds the ability or capacity to eat this much unless grain is substituted for part of the hay. Also, pregnant ewes frequently show a decline in appetite or voluntary feed intake during the last 1 to 2 weeks of pregnancy. The reason for this

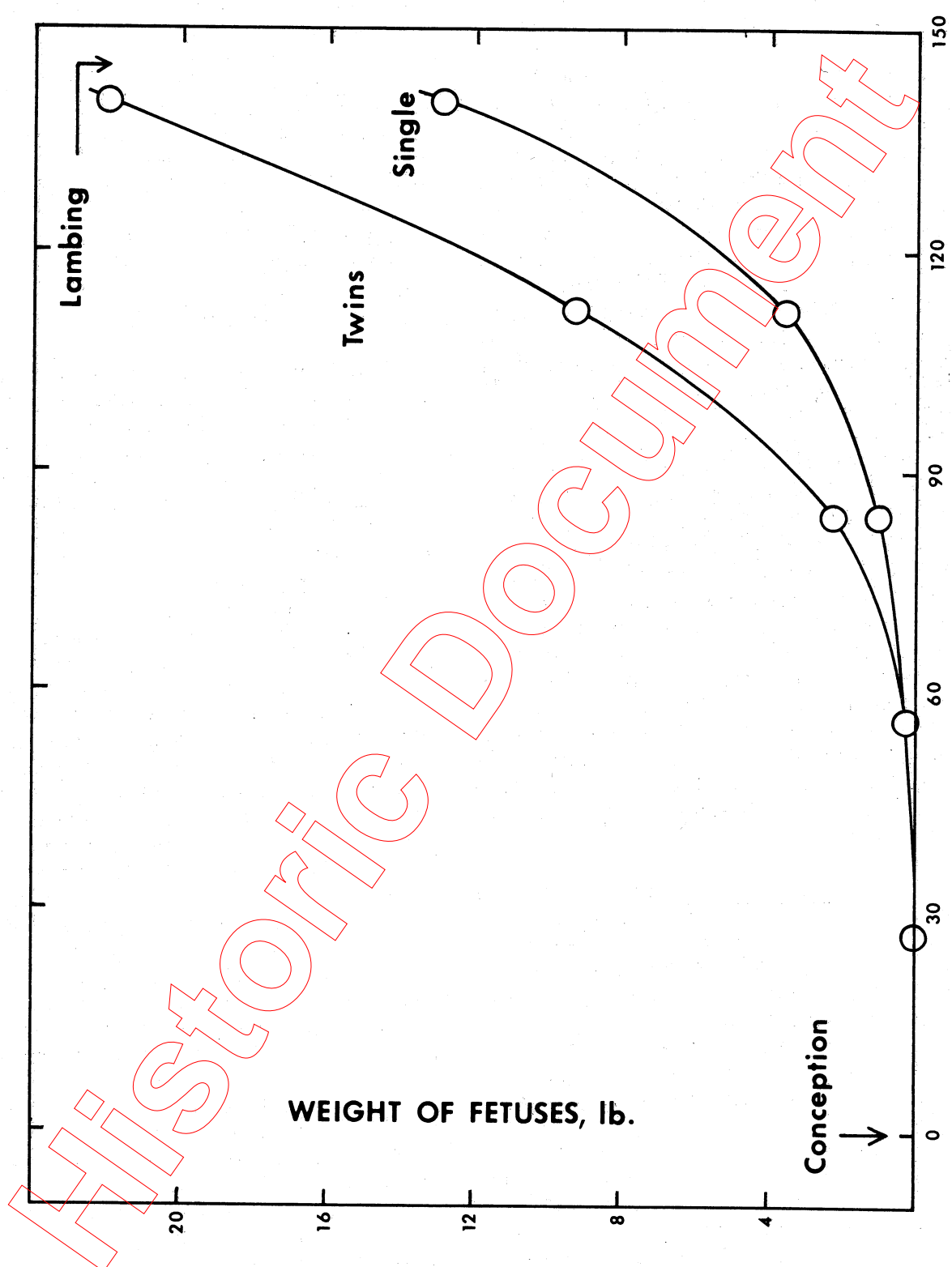


Figure 1. Growth of the unborn lamb during pregnancy (calculated from Wallace, 1948).

decrease in appetite is not clear, but it does occur more frequently in fatter ewes.

Another factor that seems important to the nutrition of the pregnant ewe is the protein content of the diet. The protein requirements for both pregnant and lactating ewes is listed by the National Research Council as only about 8 per cent of the total ration. In view of the high fetal growth requirements and the use of protein for glucose synthesis by the animal, it may be that this level of protein is too low and higher amounts are needed especially if pregnancy toxemia is a problem.

The level of nutrition and management during pregnancy is an important factor in the prevention of pregnancy toxemia. Other factors are definitely involved since an animal should be able to utilize its reserves and survive long periods of low nutrient intake or even starvation. Lactating ewes have an even higher metabolic rate and higher energy and glucose requirements than during pregnancy and do not develop a severe ketosis. During lactation, however, the animal can markedly decrease its milk production, but during pregnancy the general energy and glucose drain of the fetuses cannot be decreased as much.

Clinical Signs and Lesions: The disease is confined to the last month of pregnancy and occurs mainly in ewes carrying twins or triplets. Outbreaks frequently occur giving it a suspicion of an infectious disease. The affected ewes stand apart from others in the flock, walk unsteadily, appear dull, and are usually off-feed. Their vision may be impaired, and they show little fear of man or dogs. Blindness often results and eventually there can be convulsions, grinding of the teeth, labored respiration, and usually a mucous discharge from the nose. The mortality rate is about 80 per cent with death usually occurring in from 2 to 10 days. If lambing occurs, the ewe often quickly recovers. The urine is acid and contains an excess of acetone or ketone bodies. In terminal cases, the animal may be hydrated and generally acidotic but

this is not as severe as in diabetes mellitus. A shock-like state eventually occurs.

Treatment: Treatment of field cases in the undernutrition type often is unsatisfactory, and most attention should be given to preventing further cases. The best treatments so far are glycerol (glycerine) and glycerol plus insulin. This treatment improved the survival rate from 20 per cent in untreated groups up to about 40 to 60 per cent in the treated groups.

All animals, of course, should be encouraged to eat and other supplements such as molasses can be given. Amino acid hydrolysates, or sodium lactate given intravenously or orally may help by increasing glucose formation and by controlling any acidosis. Calcium and magnesium borogluconate injections may also be helpful.

Prevention: Although much is yet to be learned about pregnancy toxemia, the incidence of the disease can be minimized by careful management and proper nutrition. Since about 80 per cent of the growth of the unborn lamb occurs during the last 6 weeks of pregnancy, it is obvious that the feed intake of the ewe should be increased during this period. This writer believes that 8 per cent protein may be too low in many instances and that more protein should be given. Also, most ewes should gain 20 or even up to 30 pounds during the 6 weeks before lambing. The growth of the unborn lamb (Fig. 1) is only about 60 per cent of the total uterine contents.

The usual consensus of opinion is that ewes should be in only medium condition and not fat. Therefore, during the first half of pregnancy, over-fatness should be reduced and weight gains should be allowed during only the six weeks before lambing. Overly fat ewes seem more susceptible to the stress type of pregnancy toxemia. Ewes late in pregnancy should be treated with considerable care at all times to minimize both physical and psychological stresses. Feed never

should be withheld and transportation avoided if possible.

Prevention and Control of Diseases Affecting the Feet of Sheep

FOOT ROT

Foot rot is highly infectious and may acutely affect as many as 75 per cent of the flock at one time causing extreme lameness and loss of condition. The infection may be carried by moderately affected sheep for extended periods of time with no signs of limping. This type of infection gives the impression of normalcy; hence, the erroneous opinion that the causative organisms live and remain infectious in soil for extended periods of time is prevalent.

Although the mortality rate from foot rot is low, loss of condition of adults and nursing lambs plus increased labor, equipment and materials to treat the disease make it perhaps the most costly of sheep diseases.

Foot rot is world-wide in distribution, but is seen infrequently in areas of sandy, well-drained soils and regions of low rainfall.

Etiology: The lesions of foot rot are caused by a dual infection of *Fusiformis nodosus* and *Spirocheta penortha*. Infection may persist for years in the feet of sheep, but dies in soil usually within 14 days.

Transmission: Walking over contaminated pastures or areas where infected sheep have been previously is the method of transmission. Most severe outbreaks occur during warm moist weather. Furthermore, concentration of large numbers of sheep in small areas contribute to the rapid spread of the infection. Skin penetration by the larvae of *Strongyloides spp* may be a disposing factor.

Clinical Signs: Foot rot usually starts between the digits in the region of the heels, with initial swelling and moistness of the skin. The inflammation

is accompanied by slight lameness which increases as necrosis under-runs the horn. As the infection spreads in the foot in both the sole and the wall, lameness becomes more severe. There is a foul characteristic discharge, but abscessation does not occur. As the disease progresses and becomes chronic, the hoof growth often becomes distorted and frequently sheep will put little or no weight on an affected foot.

Treatment and Control: To effectively treat and control foot rot, inspection of all feet of all sheep in the flock is required. In order to make adequate progress, a control program should be initiated during the dry season or at least when rainfall is minimal.

Inspection should be accompanied by trimming with secateurs and a knife, paring away all infected tissue. Since the response to medication is much more favorable, it is extremely important that no necrotic tissue be left.

A general outline of a flock foot rot control program consists of:

- (1) Trimming all feet of every sheep and treating in foot bath.
- (2) Identifying affected sheep and isolating as a hospital flock.
- (3) Re-treat affected sheep a minimum of every three days for at least four consecutive treatments.
- (4) Inspecting infected sheep every two weeks.
- (5) Recovered sheep go to convalescent flock.
- (6) Sheep in convalescent flock that pass two clean inspections 30 days apart and are treated at the time of each inspection may go to clean flock.
- (7) Infected flock should have treatment continued as the individuals require it.
- (8) Clean flock must pass two inspections 30 days apart with no infected sheep being removed and flock must be inspected twice yearly.

- (9) Any new sheep must be isolated and pass inspections 30 days apart before being introduced into the flock.
- (10) When flock is inspected, clean sheep must go to a pasture which has had no sheep on it for two weeks.

Treatment:

Individual:

- (1) Formaldehyde 10 per cent solution.
- (2) Chloramphenicol 10 per cent suspension
- (3) Copper naphthenate
- (4) Iodophor tincture 2 per cent

Group: Foot Bath

- (1) Copper sulfate -- saturated solution
- (2) Formaldehyde 5 per cent solution
- (3) 2, hydroxymethyl-2-nitro-1, 3 propanediol diluted 1 gallon per 17 gallons water
- (4) Iodophor concentrate diluted 2 ounces per gallon concentrate undiluted.

These materials should be used with caution as they are toxic to humans.

FOOT ABSCESS

Foot abscess is a widespread disease which is sporadic in occurrence. It is infectious but not contagious as is foot rot or foot scald.

The conditions under which foot abscess occur may be varied and are related to several contributing factors. Foot abscess may occur under extremely wet or muddy conditions; as a sequel to severe trimming in wet weather; when sheep have been placed on stubble, particularly barley or safflower stubble; and in conjunction with severe outbreaks of foot rot.

Clinical Signs: The earliest clinical sign is acute lameness. Sheep may hold up the affected foot. The infection

may gain entry in the toe or sole causing no visible swelling, or between the heels producing an area of granulation tissue followed by severe swelling.

In the toe type the foot will be found to be hot and tender. Frequently, a sore spot can be located, and if drainage can be established, the foot will return to normal rapidly.

When an infection invades the heel, small areas of granulation tissue may develop. The foot is painful and frequently swollen. Joints and tendons may become involved in the infection and permanent lameness may result.

Treatment and Control: Establishing drainage of pus from the claw may produce an uneventful recovery. Local use of disinfectants and antibiotics can speed recovery.

Foot baths with the same disinfectants used for foot rot have been of distinct advantage in controlling foot abscess where the infection is due to *Spherophorous necrophorous*. Frequency of use of the foot bath is directly related to the amount of mud and moisture the sheep are exposed to.

FOOT SCALD

Foot scald is a contagious disease characterized by inflammation between the claws. It occurs most commonly under wet conditions and may affect a large number of sheep in the flock at one time.

Clinical Signs: Foot scald does not develop into foot rot. In the early stages, foot scald signs are similar to those of foot rot, but in the later stages much less severe. Foot scald commences with inflammation of the skin between the claws and progresses to the rear portion of the heels producing separation from the hoof. The sheep may be slightly to moderately lame depending on the stage of the infection.

Treatment and Control: Treatment with any of the chemicals used for the control of foot rot is effective. Control of outbreaks, after foot scald has occurred, may be accomplished by walking sheep through a foot bath at weekly intervals during the wet season.

Because of the seasonal variations and the erratic appearance of foot scald, no new preventive measures have been developed. Since foot bathing effectively suppresses the disease, further control measures may not be necessary.

Bluetongue Disease of Sheep

Introduction: Bluetongue (BT) is an insect-borne viral disease, primarily of sheep and cattle, but it also affects goats and wild ruminants. It has recently been diagnosed in sheep in Indiana. The disease is often confused with other diseases of sheep, such as selenium poisoning, photosensitization, grub-in-the-head, and contagious ecthyma.

It is transmitted from infected animals to susceptible sheep by the bites of a small insect commonly called a biting midge, gnat, or no-see-um; the scientific name is *Culicoides variipennis*.

Clinical Symptoms: Signs of BT in affected sheep may be an elevated body temperature of 104 to 107°F. with a drop in the total white blood cell count. An early clinical sign usually seen is excessive salivation (wet mouth) which occurs 3 to 4 days after onset of the disease. The muzzle, lips, and mouth become reddened which progresses to a deep red color because of blood congestion, and the ears and neck region may become swollen from escape of fluids into the tissue spaces (edema). The swelling may become so severe as to completely interfere with the circulation of blood to the affected parts. This causes the parts so affected to turn white. Ulcers (sloughing of the skin and mucous membranes) appear, and a yellowish discharge usually appears at the external openings of the nose. In a severely affected animal (10 to 12 days), rumen contents may

appear on the muzzle and nostrils. The throat is usually so swollen that rumen contents are drawn into the trachea and lungs, resulting in the death of the affected sheep because of foreign body pneumonia. A severe lameness (coronitis) may occur for 12 to 18 days in infected sheep.

Prevention and Control of Bluetongue Disease in Sheep: There are 2 commercial vaccines presently on the market. These vaccines have one strain of the virus incorporated into their production. The vaccines are a modified live virus type, and this has caused some trouble in certain instances.

Listeriosis in Sheep

Introduction: Probably the major problem of listeriosis is the relationship of silage feeding to listeric infection. Many of the serious outbreaks of encephalitis or "circling disease," generalized infection or abortion occur within three to four weeks after feeding silage from a newly-opened silo. Another problem is that a much greater number of sheep than formerly thought are carriers of *Listeria* in their nose or intestine and spread the organism to their environment.

Clinical Listeriosis in Sheep: The cause of listeriosis is the bacterium *Listeria monocytogenes*. It is widely prevalent in sheep-producing areas. Of chief concern is listeric encephalitis in which the bacterium invades the base of the brain producing destructive lesions in vital areas in the brain tissue. The effects of these destructive lesions is the impairment of nervous function due to brain damage. The signs are depression, weakness, paralysis of the tongue and jaw, blindness and excessive salivation. Animals lack coordination, lose their appetite, walk in circles and push their heads against fences and other objects. Circling in the same direction is caused because brain damage is more extensive on one side of the brain than on the other. Extensive brain damage may develop rapidly so that not all

animals exhibit circling before progressive paralysis, coma and death. Conversely, clinical signs may be minimal and go unnoticed by casual observations of the animals.

Average losses from listeric encephalitis in areas where the disease is prevalent are from 2 to 4 per cent but in some outbreaks may reach 10 per cent or more.

Although not as common as encephalitis, listeric abortion may occur in ewes. Abortion occurs late in pregnancy with the ewe showing no signs of illness. The aborted fetus and placenta often are teeming with *Listeria* and constitute a hazard to the remainder of the flock and to people who handle these highly contaminated materials. Human cases of listeriosis have developed from handling infectious tissues or from inhalation of dust from dried bedding in contaminated lambing sheds.

Relationship of Silage Feeding to Listeriosis: *L. monocytogenes* will not survive in silage in an acid environment when the pH is lower than 5.6. Therefore, the organisms will not survive a good ensiling process in which, for example, in corn silage, the pH may be as low as 3.5. However, the organism will survive at the top of the silo, in pockets of spoiled silage, around the doors and other places of spoilage.

Spoiled silage often has a pH of 7.0 or higher and usually contains molds, yeasts and mixed bacterial flora. The effect of mixed microbial flora in addition to *Listeria* in spoiled silage is unknown but may be important in initiating listeric infection. Alkaline chemical additives such as urea may allow *Listeria* to persist in silage if the pH is above 7.0.

Contamination of good quality silage with spoiled silage containing *Listeria* may occur during the use of mechanical silo unloading and silage feeding equipment. It is quite probable that heavier contamination occurs when feeding silage from the top of a newly-opened upright

silo. The upright silo may be a special problem because of leaching from the spoiled areas where the pH is above 5.6 into the uppermost areas of silage which looks and smells good and thus is used for feed.

Recommendations for Prevention and Control of Clinical Listeriosis in Sheep:

Some suggestions for a listeriosis control program in sheep are summarized:

- (1) Avoid feeding silage from the top layer of an upright silo;
- (2) Avoid feeding moldy and spoiled silage if possible;
- (3) Avoid starting all of the animals on silage from a particular silo at the same time if possible;
- (4) Start sheep on silage gradually;
- (5) Provide plenty of clean drinking water. Check for adequate water intake, particularly in severe winter weather. Consider the use of water heaters in severe winter climates;
- (6) Provide clean, dry quarters during inclement weather;
- (7) Avoid stress and overcrowding;
- (8) Complete routine vaccinations and drenching for parasite control before the silage feeding season;
- (9) Avoid introducing replacement animals from flocks in which there have been clinical cases of listeriosis. Avoid introducing replacement animals from a listeric-free area into a flock which has had cases of listeriosis;
- (10) Isolate animals with circling disease or abortion from the remainder of the flock.

Bibliography of the Proceedings Sheep Diseases and Health

held at
University of California
Davis, California
September 10-11, 1968

Common Disease Problems of Feedlot Lambs
R. E. Pierson, Professor, Veterinary
Medicine, Colorado State University,
Fort Collins, Colorado

Common Diseases of Pasture-Fed and Range Lambs

Blaine McGowan, Jr., Associate Dean,
Veterinary Medicine, University of
California, Davis, California

Control of Internal Parasites in Sheep and Lambs

Norman F. Baker, Professor, Epidemiology and Preventive Medicine, University of California, Davis, California

Factors in Disease and Mortality of Lambs

C. C. Beck, Associate Professor, Veterinary Surgery and Medicine, Michigan State University, East Lansing, Michigan

Common Respiratory Problems of Sheep

Guy E. Reynolds, Associate Professor, Extension Animal Health Specialist, Oregon State University, Corvallis, Oregon

Disease Affecting the Reproductive Capacity of the Ewe

W. W. Hawkins, Jr., Head, Veterinary Research Laboratory, Montana State University, Bozeman, Montana

Diseases Affecting the Reproductive Capacity of the Ram

Robert E. Simmons, Veterinarian in Charge, Idaho Sheep Commission, Boise, Idaho

Common Metabolic Diseases Affecting Sheep

E. N. Bergman, Professor, Veterinary Physiology, Cornell University, Ithaca, New York

Prevention and Control of Diseases Affecting the Feet of Sheep

George L. Crenshaw, Extension Animal Health Specialist, University of California, Davis, California

Prevention and Control of Urinary Calculi in Sheep

H. R. Crookshank, U. S. Department of Agriculture, Agricultural Research Service, Texas A&M University, College Station, Texas

Preventing Losses in Sheep from Poisonous Plants

Wayne Binns, Director, Poisonous Plant Research Laboratory, U. S. Department of Agriculture, Agricultural Research Service, Logan, Utah
Lynn F. James, Poisonous Plant Research Laboratory

Bluetongue Disease of Sheep

John G. Bowne, Director, Animal Disease Research Laboratory, U. S. Department of Agriculture, Agricultural Research Service, Denver, Colorado

Problems Associated with the Prevention and Control of Listeriosis in Sheep

Arden H. Killinger, Associate Professor, Department of Pathology and Hygiene, University of Illinois, Urbana, Illinois

Causes for Condemnation of Lamb and Mutton Carcasses

F. B. Thorndike, Deputy Director, Western Meat Inspection Division, U.S. Department of Agriculture, San Francisco, California

Summary

Clair E. Terrill, Chief, Sheep and Fur Animal Research Branch, U. S. Department of Agriculture, Agricultural Research Service, Beltsville, Maryland

Sheep Management Systems

J. B. Outhouse
Animal Sciences Department

Introduction

Many new management systems are being developed for sheep in an effort to increase the returns per ewe per year or per acre of land allotted to the sheep enterprise.

In an attempt to review and evaluate those management systems and practices which apply to Indiana and Midwestern conditions, recommendations that can be used by producers, area agents and specialists to improve sheep production will be made.

Traditionally sheep have been raised on an extensive basis in this country as well as in other sheep countries of the world. Extensive production involves large bands of sheep, large land areas usually of low or poor productivity, low labor and capital input, low reproductive performance and low returns per animal unit. Under these conditions, sheep cannot compete with enterprises that are rapidly moving toward intensive production, involving smaller more productive land areas, higher reproductive performance, higher labor and capital inputs and higher returns per animal unit. To compete economically with these enterprises, sheep operations must also be intensified.

In the Midwest, where land values are high and where urban areas are rapidly increasing, sheep producers need to re-evaluate management systems and adapt them to changing conditions. If maximum production can be obtained, sheep will be profitable on good land and can be raised under intensive systems of production. They can produce animal food products on feeds that are presently inedible to human and thus help maintain the quality of our diets through the animal products they produce.

Review of Literature and Discussion

Following is a discussion of important management practices which need to be considered and evaluated by the Midwestern sheep producer.

Size of flocks - The average size of the flocks in Indiana in 1965 was 22.4 sheep, including ewes and rams according to a survey reported in the 1968 Indiana Sheep Day Report (Outhouse *et al* 1968). This number should be increased 10 to 20-fold to be an economical unit and to justify adequate management and capital input. Moore (1968) states that the resource efficiency, which nearly always coincides with high labor and management income in farm record programs, is the one with high labor productivity or high amounts of product produced per man. From an economic sense, a farmer must be able to handle enough brood ewes, using the latest known technology to make a standard of living equal to other alternative uses of his labor and management. Low production per unit of labor has been the stumbling block on the road to increased income from sheep for many farmers. Van Arsdall of the University of Illinois (Moore, 1968) has reported that with average methods of handling sheep one man could take care of 625 ewes per year, and with efficient methods one man could handle 1250 ewes. This could result in a return to management and labor of from \$13.75 to \$14.48 per ewe on once-a-year lambing. The decreasing numbers of sheep over the past decade would indicate that new technology has not been applied to the sheep business to make it competitive with other livestock enterprises. The big challenge in the sheep industry is to improve labor efficiency through larger units so that

labor-saving equipment and facilities can be afforded and used to lower costs of production and increase returns.

Number of Sheep Per Acre - Lewis (1968) indicates that the production of lamb and wool per acre has not kept pace with the increased yield of forages in the improved pasture areas. In many areas, forage production per acre has been significantly increased by the introduction of new or improved cultural practices, increased fertilization, new or improved plant species and in some areas, irrigation. The selective grazing habits of sheep often result in poor forage utilization when considered in terms of total production and may result in a decline in the population of the more palatable plant species. Efficient grazing of highly productive pastures requires more animal units per acre and will prevent considerable wastage of forage due to trampling and contamination.

Ways of obtaining better utilization of pastures include:

(1) The division of large pastures with smaller areas for rotational grazing with a high stocking rate by use of an electric fence. According to Parker (1966) shorn sheep can be conditioned to this type of fencing at a very reasonable cost and the fence can be moved for maximum utilization of the pasture.

(2) Varying the stocking rate to coincide with the productivity of the pasture. Van Keuren and Parker (1966) using three stocking rates of 8.3, 14.0 and 20.7 ewe lambs per acre, found that the rate a pasture is stocked has a marked influence on the animal gains as well as plant vigor, forage production and weed invasion. Too heavy a stocking rate will eventually reduce the pasture stand and forage yield, while a low stocking rate will reduce carrying capacity and result in a wastage of forage.

(3) Restricting the grazing time of the ewes. Jordan (1969) has indicated that the carrying capacity of pastures can be increased 100 per cent when dry ewes are allowed to graze 2.5 days, are

confined without feed for 2.5 days, graze one day and are confined one day per week. Lamb and wool production are not affected by this treatment.

(4) Co-graze sheep and cattle together. Numerous studies have shown that the gains of each species and the utilization of the pasture is improved by co-grazing. Van Keuren and Parker (1967) found that the ratio of 6:1 or 3:1 sheep per steer produced the best results from the standpoint of gains of the animals and the utilization of the forage when co-grazing lasted 17-18 days followed by a recovery period before re-grazing.

Maximizing the Use of Pasture for the Ewe Flock - Present recommendations tend to favor early weaning of lambs and not allowing them to graze on the same pasture with their mothers because the lambs will become heavily parasitized from the ewes. This will increase the carrying capacity of pastures because dry ewes require less feed than lactating ewes. By increasing the stocking rate and properly rotating the pasture, the condition of the ewe can be controlled during the non-lactating period (Moore 1968). Many successful sheepmen including the winners of the Ohio Master Shepherd Program (Grimshaw 1967), are weaning lambs early and finishing them in drylot or on slotted floors. If the owner wishes to utilize pasture for the ewes prior to weaning, the lambs can be separated from the ewes daily and grazed on separate pastures or remain in dry lot with the ewes returning to the lambs at night. Carter *et al* (1968) suggests that in hot weather, the ewes be grazed at night and housed with the lambs during the daytime. In either case the separation of ewes and lambs is time and labor-consuming, but can be expedited by the use of a cutting chute. Lewis (1968) feels that the lamb producer in the midwestern states should not attempt to graze lambs but should use forage to support an increase in the size of his breeding ewe flock.

Extending the Grazing Season for the Ewe Flock - The normal grazing season in Indiana and the Midwest will extend from

mid-April to mid-October on grasses and legumes commonly used in pastures. This can be extended for another month at the beginning and end of this period by the use of wheat, which can be grazed before it joints.

Where it will grow, fescue also can be used for a late fall and early spring pasture and will furnish some grazing throughout the entire winter period. In Mississippi, fescue has been used to finish market lambs from November to March (Coats 1967). Fescue is quite palatable to ewes during this period and has a rather dense sod that will support the ewes during the winter when mud can be a problem. This will permit the feeding of the ewe flock outside with a minimum of shelter, except during lambing and early lactation when the lambs need more protection. Fescue will not be too palatable during the middle of the summer, but this may be an advantage in helping to control feed intake during the non-lactating period and thus keep the ewes from getting too fat.

Winter grazing of other pastures, namely a mixture of tall oat grass, Kentucky bluegrass and timothy has shown promise at the Ohio Agricultural Research and Development Center at Wooster. In 1966, by deferring grazing from June 27 to mid-November on an early-grazed pasture to allow regrowth to accumulate, a saving of 316 pounds of alfalfa hay, 159 pounds of legume silage and 54 pounds of concentrate per ewe was realized as compared to the in-barn control group. This amounted to a feed cost saving per ewe of about six dollars (Parker and Van Keuren 1967). This management practice not only reduces the feed bill but also the labor involved in preparing harvested feeds, in winter feeding and in manure hauling.

If additional pasture is needed during mid-summer, temporary pasture crops such as sudan grass or sudan-sorghum hybrids can be used. Mayo *et al* (1966) found that the carrying capacity of these two crops was essentially the same, but the pounds of lamb produced per acre was considerably greater for sudan grass because of the lowered palatability of the

sorghum-sudan hybrid late in the summer. Ewes can be successfully maintained on either of these crops during the summer months.

As a word of caution, the ewe flock should not be grazed on legume pastures prior to or during the breeding season because legumes contain rather high levels of plant estrogens which will interfere with normal ovulation and survival of the embryo in the ewe (Pieterse and Andrews 1956), (Engle *et al* 1957). The ewe flock should be placed on a non-legume pasture about 14 days prior to breeding and maintained on this pasture during the breeding season.

Feeding Ewes According to Productivity - The nutritive requirements of ewes vary with their size, age and the number of lambs raised. Large ewes have a higher energy requirement than small ones. Old ewes or young ewes raising their first lamb will have different requirements than those between two and six years of age. Those producing and nursing twins will need more nutrients than those with singles. To save feed, the ewe flock should be divided and fed according to productivity, especially during early lactation. Dry ewes should have their feed restricted to prevent them from getting too fat and to reduce yearly feed costs.

Frequency of Feeding - Labor costs can be reduced by feeding ewes at less frequent intervals than the traditional twice a day feeding. Ample evidence exists that once a day feeding is satisfactory for both gestating and lactating ewes. Jordan (1969) reports no difference in the performance of gestating ewes fed three times a week as compared to daily feeding. Labor costs were reduced materially, however. There is evidence that gestating and lactating ewes can be self-fed if the proper concentrate to roughage ratio is maintained (Lewis 1968). Under these conditions, automated feeding of the ewe flock could be used to further reduce labor requirements. A flock of 400 ewes could be divided into two groups of 200 ewes each and fed every other day, utilizing the same feed bunks for both

groups, thus reducing equipment costs (Jordan 1969).

Age to Wean Lambs - Lambs can be weaned successfully from 30 to 60 days of age. Copenhaver and Carter (1968) reported that lambs in a Virginia study were weaned at an average age of 37 days and an average weight of 35 pounds. Conrad and Outhouse (1968) at Purdue reported an average weight of 30 pounds and an average age of 45 days. At the Dixon Springs Agricultural Center in Illinois, lambs have been weaned at six and nine weeks of age with little or no difference in rate and efficiency of gains. Outhouse (1968) in a four-year summary of an accelerated lambing program reported a 60 day weaning age as standard procedure for that program.

If early weaning is planned, Lewis (1968) recommends the following: (1) provide a palatable, high-energy creep ration as soon as the lambs will eat and be sure the lambs are eating well before they are weaned, (2) keep lambs in confinement and do not allow them to graze with the ewes during the nursing period. The protein content of the creep ration is also important. Ranhotra and Jordan (1966) indicated that rations containing 12 to 15 per cent protein were satisfactory while Copenhaver and Carter (1968) recommended 15 per cent. All workers agree that the ration should be palatable and high in energy. Most recommendations for a complete self-fed diet include a maximum of 25 per cent roughage and data from the Dixon Springs Center suggest that 12.5 per cent may result in improved gains (Lewis 1968).

Early-weaned lambs should be protected against enterotoxemia (overeating disease). This can be done by vaccinating the ewes for *Clostridium perfringens*, type C and D, by mid-gestation and the lambs two weeks before weaning (Mansfield, 1968).

There appears to be no advantage in weaning lambs after 60 days of age. Gardner and Hogue (1964) at Cornell have shown that the milk production of the ewe reaches a peak at about four weeks

following lambing and steadily declines to approximately 50 per cent by the tenth week. Seventy-four per cent of the milk is produced in the first eight weeks. After 60 days, the ewe is not much more than a companion to the lambs, and she serves as the principal spreader of internal parasites on pasture if the lambs are allowed to graze with her. Thus, early weaning can be used to effectively reduce parasite infestation in the young lamb.

Confinement Rearing of Lambs - Lambs are being raised successfully from birth to market in confinement both experimentally and commercially. While it is possible to finish early-weaned lambs on a high-quality legume pasture, free of parasite larvae, with a saving in the amount of concentrates used, the results will vary considerably with environmental factors. At Dixon Springs substantial yearly differences in lamb gains have been experienced (Lewis, 1968). These are caused by heat, excessive rainfall resulting in wet fleeces and maggot strikes, predators, bloat and numerous other factors. If a producer is to achieve maximum efficiency from an accelerated lambing program, it is necessary for the lambs to gain from .7 to .8 of a pound per day to attain market weight by four months of age. Total confinement provides the best environment for this to occur. It also permits the finishing of more lambs in a given area and is well-adapted to automation.

Total confinement does not necessarily mean barn confinement and does not preclude the use of an exercise lot when desirable. If such a lot is used, it should be devoid of forage or weed growth to reduce parasite infestation (Lewis, 1968).

Lambs also may be finished on elevated slotted floors. These may be constructed of wood slats, concrete slats, steel grids and expanded metal. Most slats vary from 1.5 to 3 inches in width with a 5/8-inch opening between them. Arehart *et al* (1968) at the Dixon Springs, Illinois station have conducted considerable research on various types of floors.

The expanded metal X-plate, wood and concrete slats made the best self-cleaning floors. Fleeces became more manure-stained on the concrete slats and the steel grids than the others. Sheep were more sure-footed and hooves wore more evenly on the expanded metal X-plate and the Safe-T-Mesh metal. Young lambs often caught one or more feet in the irregular openings of the wood floors, but these were acceptable for older lambs. Lambs gained equally well with similar feed requirements on all five test floors and internal parasites were completely controlled without drenching.

Studies were also conducted at Dixon Springs on floor space requirements using four, six, eight and ten square feet of floor space per lamb. Little or no difference in rate of gain could be attributed to the floor space available (Lewis, 1968).

The main advantages of slotted floors are parasite control, the elimination of the cost of bedding and the labor involved in frequent cleaning of pens and more even wearing of the feet. They also permit the confinement of more lambs in a given area. Their disadvantages are the cost of construction, the rapid build-up of disease organisms such as coccidiosis, sore mouth and respiratory disorders where animals are closely confined; fly control and behavioral problems associated with confinement such as wood chewing and wool picking. Mansfield (1968) recommends that feeders, waterers and mineral boxes be suspended from outside the platforms to reduce fecal contamination of feed and water. He further recommends that the feeding program provide for a break in the use of the facilities to completely clean, disinfect, and repair them and to leave them idle for a short interval in order to reduce the build-up type of disease problems. This could come at the close of a 3-4 month feeding period in an accelerated lambing program, when one group of lambs have been marketed and before the next lamb crop enters the facilities.

Accelerated Lambing Programs - The shortening of the period between lambings

appears to offer considerable opportunity to increase the productivity of the ewe flock. It also permits a much greater return on the same investment with very little increase in feed costs, labor, or equipment. In addition, it tends to even out the supply of lambs to the packer and the consumer. To date, it has been impossible to average two lamb crops per year consistently, but three crops in two years are a reality in many commercial flocks.

Doane (1966) at the University of Illinois, Carter (1968) at Virginia Polytechnic Institute, Goode (1968) at North Carolina State University and Outhouse (1966), (1968) at Purdue University have all reported successful results with accelerated lambing programs. These studies indicate that an average of 1.75 to 2.3 lambs can be marketed per ewe per year without reducing the productivity or the longevity of the ewe flock. The period of lowest fertility appears to be in the spring when the ewes must be bred for fall lambs. Kensing (1968) reports that accelerated lambing offers possibilities in Texas and the Southwest under certain conditions if management and screwworm problems can be solved.

All of the reports on accelerated lambing indicate that the Rambouillet and the Dorset are best-adapted to out-of-season breeding. The Merino and the Tunis also have this ability. The Columbia, Corriedale, Targhee and Panama which are related to the Rambouillet and the Merino show this tendency, but to a lesser degree. Many other breeds may have individuals which will produce out-of-season lambs and through selection this trait can be increased. Producers who wish to start on this program immediately, however, should plan to introduce Rambouillet or Dorset breeding into their ewe flock. Estrus synchronization can be accomplished through the use of progestins and ovulation may be enhanced by gonadotrophic hormones in pregnant mare serum (PMS) at breeding time.

For those breeds that do not adapt well to out-of-season breeding, the owners may obtain better results by

concentrating their efforts on increasing the pounds of lambs marketed per ewe on a once-a-year lambing schedule through selection for twinning and better management practices to reduce lamb mortality from birth to market.

Complete Confinement of the Ewe Flock - Interest has increased in maintaining the ewe flock in complete confinement; however, more information relative to feeding and managing sheep in this manner is needed. Proponents of this plan list the following advantages (Lewis, 1968).

(1) Harvesting and feeding forage from highly productive, tillable land will result in more complete utilization and greater production per acre than when pastured.

(2) Internal parasites will be more easily controlled.

(3) Ewes could be fed according to their needs rather than to appetite, particularly during given stages of the production cycle when proper nutrition may be more critical.

(4) Losses to predators could be more easily controlled.

(5) Automation of the feeding program would be more practical.

(6) Sheep numbers could be expanded without an increase in acreage available for pasturing or forage production.

(7) Some of the operations used in many of the accelerated lambing programs would be more easily managed.

Most of the research on complete confinement of the ewe flock has been conducted for relatively short periods. Studies need to be made on the effects on longevity, lifetime production and health and nutritional problems applying to animals continuously confined. Coop and Hill (1962) found that confined ewes required 38 per cent less TDN for maintenance than ewes allowed to graze. They

suggested that this difference was due to energy expended in walking and grazing and to climatic factors. Dahmen and Bell (1968) at Idaho, Copenhagen and Carter (1968) at Virginia and Lewis (1968) at Dixon Springs, Illinois have all confined ewes during gestation and lactation with varying results. Copenhagen and Carter (1968) indicate that Suffolk X Rambouillet ewes kept in confinement produced more lambs and weaned more lambs than similar ewes on pasture when lambing in January but did not produce nearly as well when rebred for July lambs. Dahmen and Bell (1968) found that more lambs were born and weaned to ewes on pasture. Feed costs were lower for the ewes in drylot, but labor costs were higher. They concluded that a 150 per cent weaned lamb crop is necessary if the confinement system is to be profitable. This could be exceeded through accelerated lambing which was not a part of this study.

Garrigus and Hatfield (1964), Hudson *et al* (1965) and Jordan (1969) have demonstrated that ewes can be successfully maintained on high concentrate rations through gestation and lactation. As Jordan points out, concentrates may be the cheaper source of nutrients and in confinement systems might be easier to store and automate than roughages.

Research at Dixon Springs (Lewis, 1968) indicates that breeding and gestating ewes need 10 square feet of floor space in confinement and lactating ewes need from 12 to 15 square feet for ewes and lambs. Arehart (1968) has indicated that slotted floors may be used for complete confinement of ewes throughout the year. Their use should reduce labor, eliminate bedding costs, increase the concentration of animals in a given area and may maintain better foot health. Preliminary work at Dixon Springs suggests that a pit partially filled with water under the floor may control odors and assist in fly control. If lagoons are used, a surface area of 40 to 50 square feet per sheep is necessary for anaerobic activity. Arehart suggests that pregnant ewes close to lambing be removed to a bedded area and then returned to the slotted floors with their

lambs. Ewes with multiple births should be separated from those with singles. When ewes are confined, the floors may vary from completely slotted areas with or without exercise and feed lots that are hard-surfaced to partially-slotted floors in areas where they will spend most of their time.

Plans for the complete confinement of ewes and lambs have been suggested by Simms (1967) and Ricketts (1968). These units have been designed to handle from 350 to 700 ewes on an accelerated lambing program to maximize returns and to justify the increased capital investment and higher labor costs. They involve from two to three buildings which have dual usage for dry ewes during the breeding season, gestating ewes, lactating ewes and their lambs and a finishing area for the lambs. Roughages would be stored in silos and concentrates in bulk bins, all equipped for automated feeding. The complete cost of such a unit is estimated by Ricketts to be approximately \$75 per ewe for a 700 ewe unit. If a 200 per cent lamb crop could be marketed per ewe per year, the gross returns for the lambs, wool and culled ewes would amount to from \$55 to \$60 per ewe per year. Simms indicates that the basic feedstuffs for a 700 ewe unit could be produced on 100 acres of annual corn land utilizing corn silage as the principal roughage and corn as the principal concentrate.

Further research needs to be done on the economic considerations as well as on the nutritional and health aspects of the sheep raised under such a confinement program; however, the potential exists for maximum returns utilizing the most intensive methods of sheep production available.

Marketing Ram Lambs - Considerable evidence exists that ram lambs will produce a higher cutability carcass more efficiently than either wether or ewe lambs. Preliminary research at Purdue, (Cooper *et al* 1968), indicates that ram lambs will gain 26 per cent faster than ewes after weaning (.83 vs. .66 pounds average daily gain) and have an 18 per cent greater feed efficiency (4.02 vs.

4.94 pounds per pound of gain). Ram lamb carcasses graded comparable to ewe carcasses at slaughter and sold for the same price.

Hogue (1968) has reported that ram lambs of comparable weight to ewes and wethers have a higher percentage of the carcass in the major retail cuts and a lower percentage of fat in the carcass.

Under these conditions, the practice of castrating ram lambs for market purposes needs to be re-evaluated. If the marketing of ram lambs is to be successful, they must be fast-growing and marketed at approximately four months of age before they develop secondary sex characteristics that may lower their carcass quality and grade.

General Considerations - For an intensive sheep production program on an accelerated basis to be successful, the breeding flocks must be composed of ewes that will produce twin lambs with an inherent ability to weigh from 100 to 110 pounds in 120 days on 400 pounds or less of high-energy feeds. These lambs must produce a high cutability carcass and return a profit to the producer. While lamb production should be the major effort of such a program, large white-faced ewes with some fine wool breeding will produce a heavy shearing fleece that can add additional income to the operation. Increased growth and vigor can be obtained through heterosis by crossing these ewes with large mutton-type rams.

Hogue (1968) at Cornell University has made an extensive study of factors affecting lamb carcasses. He recommends that all lambs be slaughtered at a standard weight of 110 pounds and that they be produced by parents of relatively large size, since the composition and yield of retail cuts are related to the mature size of the parents. In a study in which large (150 pound) and small (105 pound) ewes were bred to large (260 pound) and small (120 pound) rams, he concluded that lambs produced by large rams had less fat trim in the carcass

and required less feed to reach market weight. The large ewes required more feed than the small ewes but had a higher reproductive rate, milked heavier and produced lambs with leaner carcasses. Ewes producing twins required more feed than those with singles, but on a market lamb basis each twin was produced on 25 per cent less feed than singles. From this study Hogue recommends the use of large rams on moderate to large-sized ewes that are selected primarily for twinning.

The commercial producer as well as the purebred breeder must rely on performance and progeny testing to make intelligent and accurate selections of replacement breeding stock.

Summary

A number of management systems have been reviewed and discussed. Some of these are presently being used by producers with good results. Others need more investigation before they can be recommended. All offer opportunities to increase the returns and economic status of the sheep industry in Indiana and the Midwest.

Those that have been well-accepted include (1) the early weaning of lambs, (2) confinement finishing of lambs for market on high-energy diets with or without the use of slotted floors, (3) accelerated lambing with those breeds that will mate out of season naturally, and (4) the selection for larger parent stock that have the inherent ability for twinning.

Practices that have not been widely used but can be recommended, based on available research data, include (1) an increase in the size of flocks to make them an economic unit of production, (2) intensifying the number of sheep per acre, (3) maximizing the use of pasture and extending the grazing season for the ewe flock, and (4) feeding according to productivity. These practices will help to intensify sheep operations on good land and reduce feed costs. The use of slotted floor barns, automation and less frequent

feeding or self-feeding will help to reduce labor costs.

Those practices which offer real possibilities but need more investigation include (1) the complete confinement of the ewes and lambs and (2) the marketing of ram lambs.

Each producer must evaluate and utilize those management systems which will bring him the greatest net returns from his sheep operations.

Literature Cited

- Arehart, L. A., 1968. *Management of sheep on slotted floors*. Sheep Breeds and Sheepman. Vol. 88: No. 6, 24-25.
- Arehart, L. A., J. M. Lewis and H. A. Cate. 1968. *Slotted floors are practical for lambs*. Illinois Research 10: 10-11.
- Carter, R. C., 1968. *Intensive lamb production systems (Part One). The early weaning multiple lambing confinement rearing system*. The Shepherd. Vol. 13: No. 4, pg. 14.
- Carter, R. C., J. S. Copenhaver and F. S. McClaugherty. 1968. *Intensive lamb production from pasture*. Virginia Res. Rpt. 126: 56.
- Coats, R. E., 1967. *Finishing Lambs on winter pasture*. Mississippi Farm Research 30: No. 11, 1.
- Conrad, J. H. and J. B. Outhouse. 1968. *Energy requirements of ewes on an accelerated lambing program*. Purdue Sheep Day Report. June 28, 1968.
- Coop, I. E. and M. K. Hill. 1962. *The energy requirements of sheep for maintenance and gain. No. 2 Grazing sheep*. J. Agr. Sci. 58: 187.
- Cooper, P. O., J. H. Conrad, J. B. Outhouse and R. B. Harrington. 1968. *High concentrate diets for early-weaned lambs*. J. Animal Sci. 27: 1162 (Abstr.).

- Copenhaver, J. S. and R. C. Carter. 1968. *Very early weaning (Confinement rearing of lambs) rebreeding ewes for multiple lambing*. Virginia Res. Rpt. 126.
- Dahmen, J. J. and T. Donald Bell. 1968. *Drylot versus pasture managed ewes. Phase VII*. Idaho Agr. Res. Rpt. No. 137.
- Doane, B. B. 1966. *Accelerated lambing*. Illinois Agr. Exp. Sta. Rpt. AS-639e.
- Engle, P. H., D. S. Bell and R. R. Davis. 1957. *The effect of ladino clover, birdsfoot trefoil and bluegrass pasture on the rate of conception among ewes*. J. Animal Sci. 16: 703.
- Gardner, R. W. and D. E. Hogue. 1964. *Effects of energy intake and number of lambs suckled on milk yield, milk composition and energetic efficiency of lactating ewes*. J. Animal Sci. 23: 935.
- Garrigus, U. S. and E. E. Hatfield. 1964. *High concentrate diets for gestating and lactating ewes*. J. Animal Sci. 23: 1208.
- Goode, L., 1968. *Intensive lamb production*. Sheep Breeder and Sheepman. Vol. 88: No. 2, 32-36.
- Hogue, D. E., 1968. *A sheep production model for maximum nutritional efficiency*. Symposium on Sheep Production and Business Management. Ohio Agr. Res. and Dev. Center, Wooster, Ohio, December 4-6, 1968.
- Hudson, F. A., R. M. Durham, F. G. Harbough, C. T. Gaskins and D. W. Zinn, 1965. *Drylot performance of ewes fed an all-concentrate ration*. Proceedings, Western Section, Amer. Soc. Animal Sci. 16.
- Jordan, R. M., 1969. *Profitable management of sheep*. Sheep Breeder and Sheepman. Vol. 89, No. 3: 6-11. (March 1969).
- Kensing, R. H., 1968. *Production, management and cost comparison of accelerated lambing and early weaning on southwest range operations*. Symposium on Sheep Production and Business Management. Ohio Agr. Res. and Dev. Center, Wooster, Ohio, December 4-6, 1968.
- Lewis, J. M., 1968. *Confinement systems of ewe and lamb management*. Symposium on Sheep Production and Business Management. Ohio Agricultural Research and Development Center. Wooster, Ohio, December 4-6, 1968.
- Mansfield, M. E., 1968. *Health problems in intensive sheep operations*. Symposium on Sheep Production and Business Management. Ohio Agricultural Research and Development Center, Wooster, Ohio, December 4-6, 1968.
- Mayo, Henry, C. H. Noller, J. A. Osborn, J. B. Outhouse and C. L. Rhykerd, 1966. *A comparison of temporary summer pastures for lambs*. Purdue RPR-256.
- Moore, John E., 1968. *Economic considerations in the sheep business including maximum use of pasture in intensified operations*. Symposium on Sheep Production and Business Management. Ohio Agricultural Research and Development Center, Wooster, Ohio, December 4-6, 1968.
- Outhouse, J. B., 1966. *Summary of accelerated lambing program*. Purdue Sheep Day Report., June 25, 1966.
- Outhouse, J. B., K. J. Drewry and H. H. Mayo. 1968. *Indiana sheep production survey*. Purdue University Cooperative Extension Publication AS-381.
- Outhouse, J. B., 1968. *Four-year summary of accelerated lambing program*. Purdue University, Cooperative Extension Publication AS-383.
- Parker, C. F., 1966. *Electric fencing for sheep*. Reprinted from Ohio Agr. Res. and Dev. Center. Rpt. 51 (4): 59-60.

- Parker, C. F. and R. W. Van Keuren. 1967. *Winter pasture for sheep*. Reprinted from Ohio Agricultural Research and Development Center Rpt. 52 (5): 69-70.
- Pieterse, P. J. S. and F. N. Andrews. 1956. *The estrogenic activity of alfalfa and other feedstuffs*. J. Animal Sci. 15:25.
- Ranhotra, G. S. and R. M. Jordan. 1966. *Protein and energy requirements of lambs weaned at six to eight weeks of age as determined by growth and digestion studies*. J. Animal Sci. 25: 630.
- Ricketts, G. E., 1968. *Planning a total confinement unit*. Symposium on Sheep Production and Business Management.
- Ohio Agricultural Research and Development Center, Wooster, Ohio, December 4-6, 1968
- Simms, R. H., 1967. *Confined lamb producing systems*. Sheep Breeder and Sheepman. Vol. 87: No. 3, 8-11.
- Van Keuren, R. W. and C. F. Parker. 1966. *How stocking rate affects pasture gains*. Reprinted from Ohio Agr. Res. and Dev. Center Rpt. 51 (6): 88-89.
- Van Keuren, R. W. and C. F. Parker. 1967. *Grazing sheep and cattle together*. Reprinted from Ohio Agr. Res. and Dev. Center Rpt. 52 (1): 12-13.

Sheep Production and Business Management Symposium was held December 4-6, 1968, at the Ohio Agricultural Research and Development Center, Wooster, Ohio.

The information given herein is supplied with the understanding that no discrimination is intended and no endorsement by the Indiana Cooperative Extension Service is implied.

Developments in Sheep, Lamb and Product Marketing

*J. H. Armstrong, H. V. Courtenay and M. D. Judge
Agricultural Economics and Animal Sciences Departments*

Introduction

The primary objective of this discussion is to briefly cover some of the major findings of the marketing project portion of the Sheep Industry Development Study. Naturally, all of the issues discussed are not in final form, nor are they necessarily final conclusions or recommendations. The project is still in progress. Furthermore, some of the items mentioned involve circumstances and situations which may require additional research before they can be solved.

To get a first-hand overview of the sheep industry, we visited operations of all facets of it - ranching, feeding, live selling, slaughtering, processing and distribution. Conferences were held with management in about 50 plants which account for the slaughter of 6.5 million lambs out of the 13 million total U. S. annual slaughter.

Six major issues were selected for this discussion.

Production Developments as They Affect Marketing

An early estimate of sheep numbers showed a peak in sheep and lambs on farms in the U.S. of about 53 million head in 1884, numbers peaked again near this level in 1909 and 1932 and reached an all-time high in 1942 at about 56 million head. Since 1942 sheep numbers have been in an almost continuous decline reaching the 21 million level on January 1, 1969.

Per capita consumption of lamb has followed this production decline. From a consumption level of nearly 7 pounds during the early 1940's, lamb has declined to about 3.8 pounds per capita. The latter level has been sustained only through increased efficiency in U. S. sheep and lamb production, increased dressed weights, and increased importation of lamb and mutton.

The sheep and lamb industry, like other livestock industries suffers, from relatively high fixed costs of such factors as land, equipment, and increased labor costs. However, the cost-price squeeze has not necessarily been limited to the production phases of the industry.

In slaughtering, processing and distribution there is continual pressure to increase the volume handled per employee because of short supply, low volume and the problem of handling a small carcass animal.

From the standpoint of live marketing, there are numerous problems. Sheep and lambs continue to be produced in all 50 states; in relatively small production units; with wide variation in size and quality of animals; and wide seasonal variation in time of marketing. This dispersion of production coupled with declining volume has resulted in increased costs associated with assembly, standardization, transporting, and slaughtering. Only in Texas, California and the mountain states, are the flock sizes sufficient to favor efficient handling and transporting in the assembly process.

Presented at 22nd Annual Reciprocal Meats Conference, California State Polytechnic College, Pomona, California, June 11, 1969.

Cooperative Extension Service, PURDUE UNIVERSITY, Lafayette, Indiana

The decline in slaughter volume has been accompanied by an attempt on the part of slaughterers and processors to consolidate slaughtering facilities for maintenance of efficient operations. Consequently, there has been a rapid decrease in number of plants slaughtering sheep and lambs so that now there are only 30 to 40 plants of significant volume slaughtering lambs in the United States. This leaves many areas without adequate slaughter facilities and poses increased problems for assembly and transport of live lambs.

It is expected that the number of farms producing sheep and lambs will continue to decline for several years. Also, while a large number of large scale commercial flocks will continue, the average size of the flock, particularly in the farm flock states, will remain relatively small.

Recent declines in numbers of markets handling sheep and lambs and plants slaughtering them will continue. This will further complicate the assembly and transport of sheep and lambs, and increase these costs. The lack of alternative market opportunities and the long distances to slaughter plants is now extremely critical in many areas of the farm flock states.

On the other hand, recent and prospective improvements in transportation could have many implications for the sheep and lamb industry. Already inter-regional shipments of feeder lambs, slaughter lambs, slaughter ewes and sheep and lamb products are commonplace, making the total United States one large sheep and lamb market. The possibility of air freighting, particularly for lamb products between regions and even countries, is already a reality.

Considering these developments, sheep and lamb producers may have to arrange to perform the assembly, transport, and market information functions in the future through their own individual or cooperative efforts or rely on dealers and less than optimum market outlets.

Our total United States supply of sheep and lambs comprises not only domestic production but also our imports of these products.

International Trade in Sheep and Lamb Products

Net imports of sheep and lamb products have increased from about 6 per cent in 1958 to almost 25 per cent of U. S. production in 1968. Certainly an increase of this amount in the last decade during a period when domestic production has been declining has given considerable concern to the U. S. sheep industry.

It is important to note that imports are primarily mutton. In 1968 total imports were approximately 147 million pounds (carcass weight equivalent) of which about 124 million pounds was mutton and 23 million pounds lamb. It is estimated that mutton imports represent about 3 times our estimated domestic mutton production whereas lamb imports constitute only about 4 per cent of our domestic lamb production.

Because of the difference in the end use, lamb versus mutton, they have been analyzed essentially as separate products.

Lamb Imports - It has often been suggested that imports of lamb should be scheduled during low U. S. production periods to supplement and complement the U. S. marketing program. However, recent data leads one to question whether this has been accomplished to any great extent. Imports in general have tended to move in the same direction as domestic production. As a result, increases in lamb importations could have a depressing effect on domestic lamb prices.

Mutton Imports - U. S. mutton production is primarily a by-product of the sheep and lamb industry. U. S. mutton production is small - estimated at about 35 million pounds in 1968 compared to 124 million pounds of mutton imports. While mutton imports have fluctuated rather widely during recent years, price fluctuations between these years on an annual

basis have not always been in a traditional supply and demand relationship. Analyses indicate that there is a relatively little relationship between the supply of mutton and prices received for cull ewes by producers. This suggests that there are other factors, perhaps world market prices, influencing cull ewe prices.

Implications of this data indicate in the future imports, particularly of lamb, could become increasingly significant in terms of their effect on domestic prices. Further improvements in the product form and quality of imported products could result in their having an even greater impact on U.S. domestic prices.

One possible way in which the U.S. sheep industry may improve their competitive position, particularly with respect to imports of lamb, is through the production of a more readily acceptable, meatier lamb.

New Grades for the Industry

For many years the industry has had grades for quality, prime, choice, etc., which were designed to distinguish differences in meat palatability and cooking characteristics including flavor, tenderness, etc. While these grades have served the industry well in the past, more recently a factor of possibly greater economic value to the industry has evolved namely the lean-fat ratio or amount of boneless trimmed retail cuts in the carcass. To facilitate measurement of this factor, carcass yield grades were developed. These grade standards are useful in identifying lamb carcass merit by specifying the carcass lean-fat relationship in quantitative terms. They represent a tool with which the industry can communicate more accurately value differences throughout the production, marketing and pricing system.

Among the traits used to predict carcass yield, the most dependable one is the measure of fat thickness over the center of the ribeye muscle between the

12th and 13th ribs. This measurement is sometimes adjusted to account for unusual quantities of fat over the rump, at the 5th rib and in the body wall.

The amount of kidney and pelvic fat is many times unrelated to the thickness of fat over the ribeye. Consequently, the percentage of the carcass represented by such fat makes a valuable contribution to the estimation of retail yield.

The conformation grade of the legs is not highly correlated with retail yield, but it is useful in the overall prediction. This factor is evaluated subjectively and coded (1 = low cull, 15 = high prime).

The yield grade standards are based on a multiple regression prediction equation:

$$\text{Yield grade} = 1.66 - (0.05 \times \text{leg conformation grade code}) + (0.25 \times \text{per cent kidney and pelvic fat}) + (6.66 \times \text{adjusted fat thickness over the ribeye, inches}).$$

The fractional part of the yield grade is dropped resulting in yield grades 1 through 5. They correspond to the following percentages of retail cuts:

Yield grade	Yield of cuts
1	47.3 per cent and over
2	45.5 to 47.2 per cent
3	43.7 to 45.4 per cent
4	41.9 to 43.6 per cent
5	Less than 41.9 per cent

Increased understanding and use of the carcass yield grades can be an important aid in both producing and marketing a higher value more readily consumer acceptable lamb.

In the whole sheep industry production/marketing complex changes in marketing institutions and in production institution and practices act upon one another resulting in various synergistic changes.

Processing, Slaughtering and Distribution

In visiting slaughtering and processing plants throughout the entire country, there are some rather striking differences between those in the eastern and western United States. Most of the slaughtering facilities for lamb in the east tend to be relatively old, inefficient plants, located in cramped areas of big cities where remodeling and expansion seem difficult or impossible. Also, the number of plants in the east that are handling lamb is diminishing rapidly. This is especially true of the smaller operations.

Slaughtering facilities in the western half of the United States are larger, more modern, and generally more efficient. Most are well-located and have room for remodeling or expansion. While many small or medium-size slaughtering operations in the western portion of the country are also quitting the lamb business, many of the larger more specialized ones are maintaining current volumes and in some instances even expanding slightly. The trend would appear to be toward a future pattern of lamb slaughter facilities characterized by about a dozen large specialized operations. Each handles one-half to a million lambs annually and is located near the major sources of supply; Texas, California, Colorado, Washington, Oregon, Utah, Iowa, Minnesota, and possibly one or more in the eastern portion of the U.S. as long as the kosher market requires local slaughter.

A major trend being discussed by almost every packer, processor and distributor is that of centralization and concentration of lamb fabrication. To gain more efficient productivity and improve their cost and profit situation the food industry is turning, somewhat reluctantly and hesitantly, to centralized fabrication of meats into block-ready and/or counter-ready cuts. A common and pertinent question is "Who will do the centralized fabrication - packer - processor - or chain warehouse?" The answer at this point, however, appears to be a purely academic one as to who will do it and not whether it will or will not be done.

Lamb retail distribution and consumption is concentrated primarily on the east and west coasts. In fact, an adequate retail distribution system on a national scale is very much lacking. If lamb should shift from being a staple meat item on the two coasts to being a more specialized item as it is elsewhere in the nation, a more adequate national retail distribution system is critical. Particularly, if supply remains near current levels, and present prices are to be maintained.

An important point in retail distribution is that many merchandising managers claim they can influence lamb sales by as much as 50 to 100 per cent in any one area by changing the number of linear feet of display, featuring lamb sales, promotions, and by the general method in which the product is presented to the consumer. Retail stores usually allocate display space to lamb proportionate to its percentage of the over-all meat volume. Most stores feature it 6 to 12 times a year.

These are some of the changes in marketing institutions and practices that reflect needed adjustments back through production as well as pointing toward modifications and innovations needed in the final product form.

Product Form and Development

The merchandising of lamb to date has been accomplished basically as a fresh meat product. Research has shown that lamb carcasses are particularly susceptible to temperature change in the environment since their size permits quick uptake of heat as compared to items the size of beef carcasses. Temperature elevations permit rapid growth of microorganisms on any free moist surfaces. Therefore, much attention has recently been given to some alternatives for transporting fresh cuts or carcasses in the distribution channels, as well as to produce forms other than traditional fresh cuts. One relatively recent innovation is the packaging of saw-ready wholesale cuts in flexible packaging materials. While only limited use has been made of flexible packaging for wholesale processing

of lamb because of expense and technological problems, this packaging system has been used successfully in some instances. One example is its successful use in merchandising cuts to hotels, restaurants, and institutions.

The use of flexible films would further facilitate the development of centralized lamb cutting and processing. However, there are some problems yet to be solved before this system is widely used. The cost of wrapping individual retail cuts in these impermeable wraps may be prohibitive. The color of meat cuts wrapped in such materials is affected, although the bloom returns upon exposure to the air.

Lamb has traditionally been merchandised as fresh meat on the bone-in basis. The names of the cuts have been strongly associated with the living animal. For example, the lamb leg or the lamb shoulder. Of course, this can have various connotations for consumers. One possibility is to alter the projected image of lamb through the renaming of some of the various products and cuts. The retail cuts of lamb are similar to those of other species and could be renamed in a comparable manner.

Much interest has been expressed among processors in the use of boneless cuts and new convenient forms of lamb. The boneless leg and boneless shoulder represent products that have much greater convenience than corresponding bone-in cuts. Merchandising these boneless cuts in the form of netted roasts has been successful in some areas. The netting reduces the labor required for tying of roasts as well as holding them in a uniform shape.

Many processors and consumers feel that lamb is not made available in particularly convenient forms. Thus, a need exists for greater convenience in the preparation of fresh cuts of lamb which may mean greater emphasis on portion control and/or fabrication. Portion control, especially for the hotel, res-

taurant, and institutional grades, is now a successful practice in the industry.

No phase of meat merchandising has received more interest in recent years than the frozen meat industry. Certainly frozen or chill-pack products would permit distribution of sales over wide areas instead of restricting them to high consumption locations. However, for the present, the use of frozen cuts in hotel, restaurant and institutional processing, may be more feasible than their use at the retail level. This is primarily because the customer does not see the cut at the point of purchase until it has been cooked and served. Consequently, the appearance of the cut in the uncooked form is not important. While present cooking procedures in institutional food preparation require that the cut be in the thawed form and ready for quick preparation the development of new methods of heating such as infra-red and microwave cooking, would facilitate cooking from the frozen state.

Considerable resistance to frozen cuts at the retail level has been expressed by meat merchandisers. It is sometimes questioned, however, whether this is largely an expression of the feelings of the meat merchandisers or the consumers which they claim to represent. Many industry representatives feel that consumer education on the use of frozen meat cuts and the gradual acceptance of these, could result in prepackaged frozen consumer cuts being a reality in the relatively near future.

Some other new product form possibilities include the combination of lamb and vegetable protein to make a low fat product which would aid in the acceptance of lamb and also provide a so-called health food or speciality item for diet enthusiasts. Some processors have also indicated an interest in preparation of such items as canned legs, prepacked frozen shish-kabobs, and ground meat products that combine lamb with other meats. Certainly current research has emphasized the need for greater variety of manufactured lamb cuts and products.

Attitudes and Opinions In the Sheep Industry

Out of attitudes and opinions come action. For this action an important portion of our study of the sheep and lamb industry has been to determine the individual feelings of people in various segments of the industry.

Starting with the retailer end of the production through the marketing complex, we found that more retailers were cautiously optimistic than outright pessimistic concerning future handling of lamb. Some typical statements were, "Lamb is basic in our meat department, we can't eliminate it;" and "We need lamb to add variety to our meat department." Other retailers, particularly in the west, were more pessimistic, except for the independent food stores or small local chains who made lamb the specialty of the house. One large voluntary chain meat manager commented that "lamb is a necessary evil, like fish it's the last thing the butcher wants to fool with." But another operations manager in a similar large chain said, "I like lamb, it's a good profit item." It is obvious that it is important for the sheep industry to be closely coordinated with the large retail food chains and to keep dialogue with their leaders relative to their needs, preferences, and policies. Food chains now seem to have usurped much of the power in the meat world that was held by the packers 25

years ago. Packer feeling concerning lamb slaughtering and processing varied widely depending upon their present status in the industry, status of processing equipment and the attitudes of management. Opinions tended to be evenly divided regarding whether or not lamb would be profitable in the future, even though most said it was worthwhile now. In many instances, larger plant operators are picking up the supply and the markets being dropped by the small operators who have recently quit handling lambs. Eastern packers were generally somewhat unhappy with respect to lamb supplies and lamb quality. While western packers were more optimistic with respect to volume expecting it to increase some, and were more optimistic about new product forms, and about the possibilities for lamb in the hotel, restaurant and institutional trades.

Growers attitudes showed a mixture of pessimism, cautious optimism, and perhaps even more noteworthy -- the pain of decision-making in a period of change and transition in the industry. Certainly many producer attitudes are colored by the impact they feel recent developments in the industry will have on their individual situations.

In summary, there is sufficient optimism in all segments of the industry so that changes are occurring which have the potential to increase the competitive position of the sheep and lamb industry.